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HEARING

ON

NATIONAL DEFENSE AUTHORIZATION ACT FOR FISCAL YEAR 2013

AND

OVERSIGHT OF PREVIOUSLY AUTHORIZED PROGRAMS

BEFORE THE

COMMITTEE ON ARMED SERVICES
HOUSE OF REPRESENTATIVES
ONE HUNDRED TWELFTH CONGRESS

SECOND SESSION

SUBCOMMITTEE ON EMERGING THREATS AND CAPABILITIES HEARING

ON

DEPARTMENT OF DEFENSE FISCAL YEAR 2013 SCIENCE AND TECHNOLOGY PROGRAMS

HEARING HELD
FEBRUARY 29, 2012

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DEPARTMENT OF DEFENSE FISCAL YEAR 2013 SCIENCE AND TECHNOLOGY PROGRAMS

HOUSE OF REPRESENTATIVES,
COMMITTEE ON ARMED SERVICES,
SUBCOMMITTEE ON EMERGING THREATS AND CAPABILITIES,
Washington, DC, Wednesday, February 29, 2012.

The subcommittee met, pursuant to call, at 3:00 p.m., in room 2212, Rayburn House Office Building, Hon. Mac Thornberry (chairman of the subcommittee) presiding.

OPENING STATEMENT OF HON. MAC THORNBERRY, A REPRESENTATIVE FROM TEXAS, CHAIRMAN, SUBCOMMITTEE ON EMERGING THREATS AND CAPABILITIES

Mr. THORNBERRY. The hearing will come to order.

Mr. Langevin is on his way, and so we will look forward to seeing him shortly. But in the meantime, we are supposed to have votes at 4:45 or 5:00, and you all could not possibly wait through all those votes, so we want to try to get to all our questions before that. So we are going to go ahead and get started.

Let me thank everybody for being here. When most of us gathered this time last year, we talked about the dangers of cutting S&T [Science and Technology] in tight budgetary times, and we are having tight budgetary times. According to our calculations, these accounts were cut about 2.5 percent. It is tempting to say it could have been worse, and obviously it could have been. And yet, part of our concern is not just the total dollar figure but how we are all spending the taxpayers' money. And so there are many topics for us to get to today, and we will do so through the course of our questions.

But let me go ahead and turn to our witnesses. And we appreciate each of you being here.

We have the Honorable Zachary Lemnios, Assistant Secretary of Defense for Research and Engineering; Dr. Marilyn Freeman, Deputy Assistant Secretary of the Army for Research and Technology; Rear Admiral Matthew Klunder, Chief of Naval Research; Dr. Steven Walker, Deputy Assistant Secretary of the Air Force for Science, Technology, and Engineering; and Dr. Ken Gabriel, Deputy Director of DARPA [Defense Advanced Research and Projects Agency].

Each of you have submitted written statements. Thank you for those. Without objection, they will be made part of the record. And if we could ask each of you to summarize your statement in about 5 minutes or so, then we will move from there to questions.

So, Mr. Secretary, I will turn it over to you to start.

STATEMENT OF HON. ZACHARY J. LEMNIOS, ASSISTANT SECRETARY OF DEFENSE FOR RESEARCH AND ENGINEERING, OFFICE OF THE UNDER SECRETARY OF DEFENSE FOR ACQUISITION, TECHNOLOGY, AND LOGISTICS

Secretary LEMNIOS. Good afternoon, Chairman Thornberry and members of the committee. I just have a few short statements that summarize my written testimony, which will be in the record.

The President's $11.9 billion request for DOD [Department of Defense] science and technology supports the President's defense strategy and reflects his commitment to ensure a strong S&T enterprise to develop the advanced capabilities upon which our men and women in uniform have come to reply upon. This request provides the necessary resources to maintain the decisive technological edge for today's challenges and the foundation to stay ahead of the most lethal and disruptive threats of the future.

The ability of the joint forces to project power and succeed in future operations is increasingly challenged by new capabilities, made possible by advances in technology, and by new tactics that employ commercial technologies in new and innovative ways. The clear technical advantage upon which our forces have come to rely, and which we currently enjoy, can only be guaranteed with a dedicated and sustained effort.

The globalization of technology, which we have discussed previously, has enabled the rise of global research and development investments and has collapsed the pace of innovation for both the U.S. and our adversaries. This has opened up new opportunities for technological surprise. It is both a challenge and it is an opportunity for exploitation.

The President's budget request provides the right mix of programs and investments in basic, applied, and advanced research to guarantee our leadership position. It includes a number of enterprise initiatives across the Department that ensure these valuable resources are invested wisely, with focus, and with the goal of accelerating the transition of concepts into capabilities for our forces.

Importantly, our success is made possible by the important work of our dedicated scientists and engineers, both in the Department of Defense and in the larger S&T enterprise that we discussed this last year. That enterprise is comprised of academia, industry, our Federal laboratories, our federally funded research and development centers, and our university-affiliated research centers. This is the most impressive collection of technical talent to be found anywhere in the world, and our budget request provides the necessary resources to keep this enterprise healthy and strong.

Mr. Chairman, thank you for the opportunity to present these brief remarks. The congressional support for the President's budget for the research and engineering enterprise will have the resources I need to ensure a strong technical base to enhance our Nation's security. And I look forward to your questions. Thank you very much.

Mr. THORNBERRY. Thank you.

[The prepared statement of Secretary Lemnios can be found in the Appendix on page 44.]

Mr. THORNBERRY. Dr. Freeman.

STATEMENT OF MARILYN FREEMAN, PH.D., DEPUTY ASSISTANT SECRETARY OF THE ARMY FOR RESEARCH AND TECHNOLOGY

Dr. FREEMAN. Good afternoon. Thank you, Chairman Thornberry and the distinguished members of the subcommittee. I appreciate the opportunity to discuss the fiscal year 2013 Army S&T program and the significant role of S&T in supporting our warfighters.

I want to thank the members of this committee for your important role in supporting our soldiers who are at war and for your advocacy of the Army's S&T investments that will sustain our technological preeminence to our future soldiers. Your continued support is vital for our success.

My vision for Army S&T is to invent, innovate, and demonstrate technology-enabled capabilities that empower, unburden, and protect our soldiers. I hear often, as I am sure you do, from soldiers themselves that technology saved their lives and was critical to their remarkable accomplishments.

When I became DAS [Deputy Assistant Secretary] of R&T [Research and Technology] a year and a half ago, I embarked on a path to change the perception that Army S&T was irrelevant. This path is leading to a significant change in the S&T culture, and it is still a work in progress. We now actively engage with senior Army leadership, the Army staff, senior executives of the laboratories and centers, and all parts of TRADOC [U.S. Army Training and Doctrine Command] to establish real priorities for Army S&T prior to the beginning of the formal Army POM [Program Objective Memorandum] cycle.

In 2011, for the first time, we collaboratively developed a set of 24 challenges on which to focus our near-term research efforts. We formulated a number of new programs to begin in FY [Fiscal Year] 2013 that address these challenges and by the end of FY 2017 to demonstrate new technology-enabled capabilities.

In the coming year, I intend to develop a set of programs to better define and prioritize the rest of the S&T portfolio. For the remainder of the 6.2 and the 6.3 funding, we will formulate programs to meet the midterm needs of the program executive offices and program managers. We will also create programs to develop and demonstrate technologies that have a high potential to bridge gaps or achieve leap-ahead technologies and capabilities.

Additionally, we will establish a set of priorities for our basic research efforts—problems and challenges against which better programs can be formulated and executed. Of course, we will do all of this in concert with the guidance provided by the Defense Strategy for the 21st Century and the OSD [Office of the Secretary of Defense] S&T priorities.

In 2013, the Army is placing increased emphasis on investment in ground and aviation vehicle survivability, research in focal plane arrays, and alternative fuels for ground vehicles. We will accept some greater risk through reducing funding in lethality, unmanned autonomous ground vehicles, and military engineering.

As we adjust to an era of decreasing or flat budgets, Army S&T must be capable of doing more with less and correctly managing the risk associated with shrinking budgets by identifying and fo-

cusing on the highest priorities for the future. I believe that the S&T management strategy allows us to do just that.

And as I mentioned last year, I continue to have major concerns with the long-term health of our laboratory—both infrastructure and workforce. And as Dr. Lemnios has said, it is important that we keep the cadre of scientists and engineers in our laboratory systems to solve our problems. It is absolutely essential that we work on this problem together, and I hope to do so with you.

While we have some basic improvements to our infrastructure through the BRAC [Base Closure and Realignment] processes, we do not have a long-term good policy or answer to how we work on our infrastructure. And we really, really need to have more discussions about that.

In closing, I would like to thank you, Mr. Chairman, for the opportunity to testify here and for your support of the Army's science and technology investments. I am proud to represent the efforts of over 12,000 Army scientists, engineers, technicians, and research professionals dedicated to our soldiers with world-class technology-enabled capabilities.

I will be pleased to answer your questions and those of this subcommittee.

Mr. THORNBERRY. Thank you.

[The prepared statement of Dr. Freeman can be found in the Appendix on page 58.]

Mr. THORNBERRY. Admiral.

STATEMENT OF RADM MATTHEW L. KLUNDER, USN, CHIEF OF NAVAL RESEARCH, U.S. NAVY

Admiral KLUNDER. Good afternoon, Chairman Thornberry, Ranking Member Langevin, and the members of the committee. It is certainly an honor to be here before you today to report on science and technology efforts within the Department of the Navy and assess how the President's FY 2013 budget request supports the Navy and the Marine Corps.

I am accompanied today by Brigadier General Mark Wise, the commander of the Marine Corps Warfighting Lab in Quantico, Virginia. He is a great partner in our effort to lead the Navy and Marine Corps science and technology community.

Our objective is to support a Navy and Marine Corps capable of prevailing in any environment, with the understanding that anti-access and area-denial threats will continue to increase in the future. We work directly with the Secretary of the Navy, the Chief of Naval Operations, and the Commandant to achieve this goal.

We do that by, one, focusing on S&T areas with big leap-ahead payoffs, but also, two, encouraging innovative thinking and business processes to make our existing systems more effective. And finally, three, we are constantly striving to improve transition of S&T into acquisition programs to enable the most cost-effective weapons systems possible. In the spirit of this striving for affordability, we are also working to strike the right balance between responsive near-term technology insertions and also long-term basic research.

While the starting point is continued evolution of current systems, we progress toward incremental improvements in spiral de-

velopment of known technologies to new development of undiscovered, disruptive technologies. Our portfolio across all the Navy and Marine Corps balances a range of complementary but also competing imperatives, in that we support advances and initiatives in existing established operational areas while still also looking at a far-reaching complement of long-term research efforts that may prove disruptive to traditional operational concepts.

Our ability to support the warfighter also depends on our ability to sustain a science and technology, engineering, and mathematics workforce in our Active and Reserve ranks and our research laboratories. We believe the key to achieving this goal lies in supporting STEM [science, technology, engineering, and mathematics] education in a continuum of experiences from kindergarten all the way through postdoctoral opportunities.

Now, I believe many of you all and certainly your staffs are familiar with many of our technology programs. If I can, I would just like to highlight two: the Electromagnetic Rail Gun and the Free Electron Laser [FEL].

Our discussions with your staff during the FY 2012 authorization process led to refinements in that rail gun program and planning, about which SECNAV [Secretary of the Navy] and I will come to you later next month to report as per the FY 2012 National Defense Authorization Act.

Similarly, the discussions within the Navy and with your staff also led to refinements in the FEL program which we intend to implement this year. In that implementation where we are focusing on components of FEL, we are also looking to mature our Solid State Laser Technology with our sister services.

We have made significant contributions to the fleet and the force's ability to share information across combat systems; command and control systems; and intelligence, surveillance, and reconnaissance systems. In the world of cyber warfare and information dominance, we do believe it is critical that we are able to integrate systems into a common information environment that is modular, based on open standards, automated, and allow for a reduction in manpower requirements and acquisition costs.

All of these issues are outlined in some detail in my written testimony, along with more detailed surveys that are enclosed in our ONR [Office of Naval Research] contributions, such as areas of irregular warfare, unmanned systems, and also medical care for our wounded warriors.

I would certainly be remiss if I did not mention the stellar contribution that is made by our entire workforce at all the Navy labs and warfare centers, with special recognition for the Naval Research Laboratory [NRL] right nearby in Anacostia. Many of your staff have visited, but I certainly invite all of you to take advantage of an opportunity to see this nearby facility firsthand. The work is absolutely impressive. The people are impressive. One of our greatest challenges, certainly, as Marilyn alluded to, is to recapitalize on our facilities—in this case, the NRL facilities—and to ensure continuation of their cutting-edge work.

I thank you again for your tremendous support, and I look forward to answering your questions. I do believe that the state of our Navy and Marine Corps S&T investments are sound. They rep-

resent good stewardship of the taxpayers' dollars. And we believe they enhance significantly the safety and performance of our warfighters today and well into the future.

And thank you, sir. I will be ready for any questions.

Mr. THORNBERRY. Thank you.

[The prepared statement of Admiral Klunder can be found in the Appendix on page 75.]

Mr. THORNBERRY. Mr. Walker.

STATEMENT OF STEVEN H. WALKER, PH.D., DEPUTY ASSISTANT SECRETARY OF THE AIR FORCE FOR SCIENCE, TECHNOLOGY, AND ENGINEERING, OFFICE OF THE ASSISTANT SECRETARY OF THE AIR FORCE FOR ACQUISITION

Dr. WALKER. Mr. Chairman and members of the subcommittee and staff, I am pleased to have the opportunity to provide testimony on the fiscal year 2013 Air Force science and technology program.

To protect our Nation amidst a myriad of current and future security challenges, the Air Force must be an agile, flexible, ready, and technologically advanced part of the joint team. The Air Force S&T program plays a vital role by creating compelling air, space, and cyberspace capabilities for precise and reliable global vigilance, reach, and power.

The Air Force 2013 President's budget request for S&T is approximately $2.2 billion, which includes nearly $200 million in support of devolved programs consisting of High Energy Laser efforts and the University Research Initiative.

This year's budget request represents a decrease of $64 million or about a 2.8 percent reduction from fiscal year 2012. This reflects a more modest reduction than taken across the total Air Force budget and indicates the strong support for science and technology from our leadership.

The Air Force S&T fiscal year 2013 President's budget request supports the following overarching priorities, as detailed in our S&T strategy.

Priority one is to support the current fight while advancing breakthrough S&T for tomorrow's dominant warfighting capabilities.

While developing technologies to equip our forces of tomorrow is the primary objective of S&T, our dedicated scientists and engineers are equally motivated to contribute to the current fight by getting their technologies into the hands of the warfighter.

For example, Air Force S&T has played a significant role in developing and delivering combat capability to our warfighters in the CENTCOM [U.S. Central Command] AOR [area of responsibility] through the deployment of a concept or a system called Blue Devil. This persistent intelligence, surveillance, and reconnaissance capability demonstrated the first-ever integration of wide-area field-of-view and narrow field-of-view, high-definition, day and night sensors cued by advanced signals intelligence. Warfighter feedback on the situational awareness provided by Blue Devil Block 1 has been overwhelmingly positive.

Priority two is to execute a balanced, integrated S&T program that is responsive to the Air Force core functions.

In light of the defense strategic guidance released last month, we ensured our current strategies and plans were appropriately aligned with new and enduring emphasis areas. Our S&T program supports the Air Force capabilities fundamental to the major priorities of the guidance, such as deterring and defeating aggression; projecting power in anti-access and area-denial environments; operating in the space and cyberspace domains; and maintaining a safe, secure, and effective strategic deterrent.

We have also engaged the small-business community in this endeavor through the Rapid Innovation Fund, which is focused on key technology areas such as supporting current contingency operations, cyberspace security, mission assurance, improved systems sustainment, and power generation and energy for our platforms.

Priority three is to retain and shape the critical competencies needed to address the full range of S&T product and support capabilities.

We are continuing to support Air Force science, technology, engineering, and mathematics [STEM] initiatives to develop and optimally manage the S&T workforce of the future through our Bright Horizons strategic document. Our newly established Air Force-level STEM outreach office ensures effective coordination with other service and agency STEM programs and gives us a better understanding of the effectiveness and impact of our STEM investments.

Finally, priority four is to ensure the Air Force S&T program addresses the highest priority capability needs of the Air Force.

Our process for creating and executing Air Force flagship capability concepts over the last 2 years is maturing well. We have continued the High Velocity Penetrating Weapon concept to demonstrate critical technologies to reduce the technical risk for a new generation of penetrating weapons to defeat difficult, hard targets. And we have continued the Selective Cyber Ops Technology Integration Program, which is executing smoothly toward providing cyber technologies capable of affecting multiple nodes for the purposes of achieving a military objective.

While the Air Force decommissioned our Responsive Space Access FCC [Flagship Capability Concept] during our annual review this year, we commissioned a new FCC for Precision Airdrop to develop technologies to improve airdrop accuracy and effectiveness while minimizing risk to our aircrews.

In conclusion, this budget request reflects our refocused S&T portfolio given budgetary challenges and the new defense strategic guidance. I believe this request also reflects the promise of future warfighting capability enabled by the technologies that will be developed with this investment.

Mr. Chairman, I thank you again for the opportunity to testify today and thank you for your continued support of the Air Force S&T program.

Mr. THORNBERRY. Thank you.

[The prepared statement of Dr. Walker can be found in the Appendix on page 96.]

Mr. THORNBERRY. Mr. Gabriel.

STATEMENT OF KAIGHAM (KEN) J. GABRIEL, PH.D., DEPUTY DIRECTOR, DEFENSE ADVANCED RESEARCH PROJECTS AGENCY, U.S. DEPARTMENT OF DEFENSE

Dr. GABRIEL. At DARPA, we are often asked to predict the future. After all, since it was created in 1958, DARPA's singular mission has been to prevent and create strategic surprise. It may appear that the best way to fulfill that mission is to predict what is next. But at DARPA we believe it is not about predicting the future, it is about building it.

Chairman Thornberry, Ranking Member Langevin, members of the subcommittee, my name is Ken Gabriel. I am the Deputy Director of DARPA.

I could discuss some of the Agency's accomplishments over the last year, including the second flight of HTV–2 [Hypersonic Test Vehicle-2] or Blast Gauge, a wristwatch-sized device to measure overpressure and TBI [traumatic brain injury]. But instead what I would like to talk to you about today is what keeps us up at night.

In anti-access and area-denial, the global electronics industry unintentionally and without malice has created vulnerabilities. Computing, imaging, and communication capabilities that as recently as 15 years ago were the exclusive domain of military systems are now in the hands of hundreds of millions of people around the world.

We don't argue against the benefits such capabilities have brought. Indeed, many of the commercial advances have roots in DARPA programs from decades past. But these vulnerabilities are not an abstract threat. Electronic warfare was once the province of a few peer adversaries. Today it is possible to purchase commercial-off-the-shelf components for more than 90 percent of the electronics in an EW [electronic warfare] system. Nearly a dozen countries are now producing EW systems at ever-increasing pace, from a new system every 10 years decades ago to one every 1½ years today.

These insights led us to new investments that leverage COTS [commercial-off-the-shelf] technology where we can and develop technologies where COTS can't or won't go. One example of leveraging COTS is the Intrachip Enhanced Cooling Program. Cooling a COTS chip allows us to, for example, run the chip 10 times faster than it was designed to run, creating differentiating capabilities for ourselves. DARPA's Adaptive RF [Radio Frequency] Technologies Program seeks to extend the range of military radar and radios by developing high-power transmit and receive modules—something the commercial industry has no use for and where COTS won't go.

In cybersecurity, there has been much focus on increasing our defensive capabilities, but we require capabilities in both defense and offense across the full spectrum of conflict. DOD tasks and purposes are sufficiently different that we cannot simply scale intelligence cyber capabilities and adequately serve the needs of the DOD. Modern warfare demands the effective use of cyber and kinetic means. That requires DOD cyber capabilities matched to our kinetic options.

We launched several programs designed to create cyber capabilities with the diversity, dynamic range, and tempo of DOD oper-

ations. Cyber Fast Track is just one such program. It taps a pool of nontraditional experts and innovators, many of them members of the "white hat" hacker community. To some, "hacker" evokes concern, but "hacker" is a positive term that describes a person of exceptional capability and creativity, someone who sees a novel use for an existing capability or technology.

In the last 7 months, more than 100 proposals were received and 32 awards were made, 84 percent of them small companies and performers who have never done business with the government before. Cyber Fast Track is expanding the number and diversity of talent contributing to the Nation's cybersecurity.

Some of these observations today feel uncomfortable, even to us. Our responsibility, however, is to the uncomfortable. They are the seeds of what allow us to fulfill our mission to prevent and create strategic surprise.

Thank you.

Mr. THORNBERRY. Thank you.

[The prepared statement of Dr. Gabriel can be found in the Appendix on page 115.]

Mr. THORNBERRY. And I really appreciate everybody being brief. This is always a challenging hearing for me because there are so many interesting things to talk about, it is hard to talk about it within the time limits that we have. But you all did a good job, and I appreciate it.

I am going to yield first to Mr. Langevin for any opening statement he would like to make and then go right ahead with any questions you may have.

Mr. Langevin.

STATEMENT OF HON. JAMES R. LANGEVIN, A REPRESENTATIVE FROM RHODE ISLAND, RANKING MEMBER, SUBCOMMITTEE ON EMERGING THREATS AND CAPABILITIES

Mr. LANGEVIN. Thank you, Mr. Chairman.

And thanks to all of our witnesses for appearing today.

Like all of us on this committee, I believe that much of our Nation's military and economic strength lies in our ability to lead the world in innovation and that the defense science and technology enterprise continues to be a major contributor to that leadership. I am pleased the President's recently released defense strategic review recognizes this. And in light of necessary fiscal tightening, his fiscal year 2013 budget request largely protects defense science and technology investments.

Portions of those funds are targeted for STEM education activities—a key investment in maintaining strong intellectual capital and technological advantage in this country. I believe all of you in your written testimony noted, to some extent, your overall interest and concern toward fostering and maintaining a world-class scientific workforce.

I share that interest and strongly believe that the Department of Defense plays an important role in the entire STEM education pipeline—a pipeline of professionals that not only develops new and improved warfighting capabilities but also prepares competent operators and maintainers of these game-changing technologies. I

look forward to hearing more from our witnesses today on each of your efforts in this area.

I particularly want to applaud you, Admiral, for the Navy's commitment to double Naval STEM investment by FY 2015. I also would like to highlight ONR's recent recognition as a leader among industry and government in promoting workforce diversity and developing strong partnerships with minority-serving institutions to advance STEM academic excellence throughout all sectors of our future workforce.

Much of the Department's basic research investment goes directly to universities to advance our understanding across a wide array of disciplines, building upon the critical investments at the K–12 level and producing benefits not only to our national security but also to the leadership of the United States in academic research and development. I firmly believe that outreach to and engagement with our youth are the best investments we can make to ensure a technological edge in the future.

Dr. Freeman, I appreciate the concerns raised in your written testimony about our defense R&D [research and development] facilities. These facilities provide needed capabilities for DOD with their uniquely skilled personnel and for our overall R&D efforts.

Labs are also key to attracting the best and the brightest to solve difficult problems. But, conversely, if not properly resourced, inadequate facilities and equipment can make it harder to attract and retain the personnel that we need, let alone stay ahead of our technological competitors.

During similar budget posture hearings, some of your Department colleagues responsible for big weapons procurement may talk about one system that, alone, could cost over $100 million. One hundred million dollars in the S&T world could mean dozens of early-stage programs or demonstration programs.

I recognize that you can't go through your entire S&T portfolio in one hearing, but I would appreciate a brief comment on areas supporting directed energy and the development and tests of technologies supporting prompt global strike objectives. And for those of who you would care to elaborate on cyber, I would appreciate that, as well.

Additionally, I believe this committee and, frankly, all of Congress would benefit from your oral statement on the implementation and early successes, if any, of the Rapid Innovation Program.

And lastly, but with special importance to myself and the chairman, I would like to take some time today to explore the critical and uniquely dynamic area of cybersecurity research and development. As we all know, the Nation faces serious cybersecurity threats and vulnerabilities that cut across ".mil," ".com," and ".gov" alike. I look forward to hearing more about the Department's research investments and strategy to develop the tools and capabilities that we need to operate effectively and securely in the cyber domain, both now and in the future.

With that, I would like to thank all of you once again for appearing before us today, and I look forward to our questions. Thank you very much.

And, with that, Mr. Chairman, I will yield back.

[The prepared statement of Mr. Langevin can be found in the Appendix on page 41.]

Mr. THORNBERRY. Do you want to go ahead and do your questions?

Mr. LANGEVIN. Sure. Very good. Thank you, Mr. Chairman.

Dr. Gabriel, if I could start with you. With the rapidly changing needs of today's warfighter, how does DARPA choose what to invest in and what to build? In other words, how do you come to the decision that a subject area is "DARPA hard"?

Dr. GABRIEL. Well, sir, as you might imagine, the challenge at DARPA is not coming up with ideas, it is choosing from among them, as you point out.

We do deep analytical analysis of thrust areas that we see as important capabilities for the Department and national security. Those analytics define and point out areas where we see divergences and where we see opportunities. We have done them in a number of areas, including cyber, which many of you have seen, the Cyber Analytical Framework.

And from those frameworks, we take the ideas and essentially ask three key questions: Is this area game-changing and will it have lasting impact? The second criteria we assess it against is, is this an area that requires DARPA expertise and capabilities? Not every idea worth doing is something that DARPA should do. The third question that we ask when we assess choosing between programs is, how does it balance the rest of our investments? Because we have limited resources in bandwidth and we must choose our investments wisely so that we can meet the mission of the Agency to prevent and create strategic surprise.

Mr. LANGEVIN. Thank you, Dr. Gabriel.

Let me turn to cyber and Secretary Lemnios.

I am pleased to see the emphasis on cybersecurity in each of your testimony here today. And I am also pleased that since last year's hearing on these matters the Department of Defense has identified cyber as one of the Department's seven key S&T areas.

Secretary Lemnios, how are you ensuring that the various defense cyber R&D efforts are both responsive to the DOD's strategy for operating in cyberspace and well-coordinated across agencies and individual laboratories?

Secretary LEMNIOS. Representative Langevin, we are—as you know, cyber is one of our Department's seven S&T priorities. We began the rebalance of the S&T enterprise for the Department about 18 months ago in identifying those priorities. And in doing so, we had long conversations with the operators—with the uniformed members of the services and the operators that would actually use those capabilities. We built a set of architectures, and we are actually now working the capability sets to develop that tech base.

With regard to cyber, I imagine you see all sorts of folks in this room that can give you opinions on how to assess the quality of cyber concepts. We have had the discussion both in the private sector and certainly in government circles.

The focus of our effort this past year has been to build a measurement framework so that we can start assessing with data how fragile our networks are, where there are vulnerabilities, and how

do we take S&T concepts, science and technology concepts, and transition those.

DARPA has been a key part of that, in developing cyber range concepts several years ago. We started to transition those well into the services and into other agencies. And across the Department, I have brought together—we have brought together the science and technology community to start working those issues in collaboration. So we, in fact, have efforts that are cross-correlated across the enterprise.

I think the focus here is the pace of innovation in cyber and how we transition those concepts. And as I have spoken with many of you before on this, that has been some of your concerns. How do we transition ideas from a research bench into an operational bench? And we are actually very focused on that.

Mr. LANGEVIN. Very good.

Obviously, one of the priorities that I have, too, is making sure that we are continuing to develop the cyber workforce and that we make sure that we have good situational awareness about who has those capabilities within the various services. And something I encourage you to consider is pressing the various services to survey in those areas.

You know, some of the brightest minds, in many ways, with cyber, they may not be the admirals and the colonels and the captains. It is going to be the newest recruits, you know, who grew up with this technology and can take to this stuff like fish to water. We ought to have a robust understanding of what those capabilities are and how we can plug them into the right fields.

Let me just turn before my time expires. Dr. Gabriel, you noted, I believe correctly, that we simply cannot scale intelligence community cyber capabilities to the needs of ".mil." Additionally, in the past, Dr. Dugan has stressed the need to address the divergence of the threats we face and the defenses that we use against them. Where do you view DARPA's niche with regards to addressing tomorrow's cyber challenges?

And for the panel, if you could comment, what do we need to change to ensure that we are better able to identify and mitigate risks in the cyber domain?

Dr. GABRIEL. So, sir, one of the ways in which we have been looking at how we can uniquely contribute in this area is recognizing that cybersecurity is not just about bits and networks; it is about the security of physical systems and embedded systems.

And an activity that we are undertaking, which we would be happy to come and talk to you in a more classified environment about, is how we, from our unique perch, are able to bring together folks from across the spectrum for that kind of threat and look at systems not only from the perspective of computer science and cybersecurity folks but EW people, embedded systems, and computer architecture, and knock down the walls between those stovepipes so that we can get an integrated look at what are the opportunities and the threats involved in that and, from that insight of the integrated look, get new capabilities and new solutions that were not possible to get from any one domain itself.

So that, along with some of the things we have talked about in the past about how we become convergent with the threat of cyber

by programs like PROCEED [Programming Computation on Encrypted Data] and CRASH [Clean-Slate Design of Resilient, Adaptive, Secure Hosts], which we have described before, which seek to attack the asymmetry of the cybersecurity challenge.

Mr. THORNBERRY. Let me get back around, if I could, so other Members can have a chance to ask. And then we will come back to this cyber, because I think Mr. Langevin asked a very good question of everybody, and I want to get back because I think everybody has a contribution to make here.

Let me just, from an overall standpoint, ask each of you to comment on your budget in the following ways: Number one, what have you done differently as a result of the new strategy, if at all?

Number two, what are you doing less of? And, Dr. Freeman, you mentioned some of this in your opening statement. The Air Force written statement gives, you know, pretty blunt, "We have to do less of this thing." And that is what we need to know, too.

So if we could just go down the line very briefly in my 5 minutes, how does the strategy affect what you are doing, and what you are doing less of that would increase risk?

Secretary Lemnios.

Secretary LEMNIOS. So, again, we started this process almost a year ago, 18 months ago, in looking at what the S&T priorities—how those line up.

In fact, I had an opportunity last fall to take about 3 months and go through the entire scope of the Department's projects—270 program elements, 30,000 briefing charts. I visited all of our laboratories and all of the programs that we could, sort of, go through. The result of that was to give me confidence that not only the dollar request but the content of that request was properly aligned. So I was looking for those places that would align—those concepts, the technical concepts that would align to the Department's strategy that came out about a month ago.

And, as a result, in the President's budget request we realigned projects. We added a big push in hypersonics. We put a big push in the Air Force in an advanced engine. We put additional funding in the Army for advanced imagers. Funding at DARPA was added in advanced manufacturing, about $300 million. We added funding in a variety of areas—electronic warfare, cyber autonomy. So we actually shaped this budget based upon a close look at the projects we had in concert with the Department's strategy.

At the OSD level, at the Department level, within my direct office, I actually reduced our staffing, and I pushed many of the projects that we were executing within OSD out to the services to execute. I think it is a far more effective way to run those. It is a tighter coupling to the services, and it results in far better transitions.

Mr. THORNBERRY. Okay. Thank you. And I realize this is hard to get in the limited time we have, but I appreciate the specifics. That helps.

Dr. Freeman.

Dr. FREEMAN. So your first question is what have we done differently in light of the 21st-century strategy that came out, and, basically, right now we have not done a lot. It has not made us change a lot in our focus, because over this last year our focus had

already shifted to the soldier and the small combat unit and what they need and the capabilities they need, which are really wherever they go, to do all the missions that need to be done. So we did not take a look at really changing anything in this budget to do that.

We did, however, intend to be—as I described, our process intends that we can actually take a look now over this next year to anything we need to do in the 6.2 and the 6.3 budget that would need to be shifted, as we look. And we did take a little extra risk, as I said, in unmanned vehicles, the command-and-control of them, focusing the additional effort in autonomy to understanding the issues that soldiers have with respect to trust of autonomous vehicles, trust of ground vehicles and being able to use them as team members. And we also took a little bit in the UAV [unmanned aerial vehicle] airborne radar world, because we just didn't have enough money to focus on more than one radar at the time. I think those are the two major efforts.

Mr. THORNBERRY. Thank you. That is exactly what I am looking for.

Admiral.

Admiral KLUNDER. Yes, Mr. Chairman, with our budget, we felt—even before the new DOD strategy came out, we certainly got enough assessments and capability gaps to understand that we needed to refocus and know where the tilt in our anti-access and area-denial focus should be.

We actually had before this DOD strategy came out in January, we had 13 focus areas for the Naval S&T strategic plan. We have now brought those down to a total of 9. I will offer that, of those nine, five of them are specifically directed toward anti-access/area-denial. That would be assured access, battle space, it would be autonomy and unmanned systems, expeditionary and irregular warfare, our information dominance in cybersecurity, and then our power projection and integrated defense. Those are the five that were brought into the A2/AD [anti-access/area-denial] specifically.

In what we haven't done, for the last number of years—and we are not patting ourselves on the back—but we have by far had the most accurate oceanographic modeling forecasting models in the world. We certainly aren't doing away with those; they are very important. But we know that at this point, in terms of maturity, we are in pretty good shape there, and those could take a slight reprieve.

I would also offer that in some of our plan form designs, we are very mature, in the ships we have designed recently and some of our planned aircraft. We think, again, right now, for this time being, we haven't done anything dramatic but we have at least reduced some of the focus there.

Mr. THORNBERRY. Okay.

Admiral KLUNDER. I think that would probably be the two areas, sir.

Mr. THORNBERRY. That is great.

Dr. Walker.

Dr. WALKER. Sir, we responded to the defense planning guidance, spent the better part of 2 to 3 months working with the lab to identify where we should lead, watch, or integrate with others and then follow, based on our core competencies as well as the new strategy.

We are all over the A2/AD area in the Air Force. We have a new investment in turbine engine—adaptive technologies for turbine engines. This is an area where we have always led and want to continue to lead. Hypersonics and supersonic activity for ALCM [Air Launched Cruise Missile] replacements and looking at how we do things quicker and over longer ranges. And then weapons for fifth-gen aircraft, we want to develop those, as well as electronic warfare as we move into A2/AD environments.

Where we had to decrease was work in micro UAVs, deployed airbase technologies, some thermal sciences, and then some plug-and-play activity for small sats that we just never got the industry to buy into.

Mr. THORNBERRY. Yeah.

Dr. WALKER. Thank you.

Mr. THORNBERRY. Okay. Perfect.

Dr. Gabriel, did the strategy affect you all?

Dr. GABRIEL. Well, sir, we are certainly informed by the strategy, but along with our own analytic frameworks which I have just discussed with you, with ISRs [intelligence, surveillance, reconnaissance] and others—position, navigation, and timing.

I can summarize that what we have done and what we are doing more of is cyber and manufacturing—cyber in particular, both defense and offense, and particularly cyber capabilities that are uniquely DOD needs vice, say, intelligence needs.

Mr. THORNBERRY. Uh-huh.

Dr. GABRIEL. In manufacturing, it is one that you have heard us talk about before: controlling for time, to get at some of the vulnerabilities associated with the increasing time that it takes us to field defense systems.

What we are doing less of is energy and autonomy, frankly. Not that we are never going to do things in those areas again, but we have finite resources and we are focusing them on cyber and manufacturing.

Mr. THORNBERRY. Interesting. Thank you.

Mr. Kline.

Mr. KLINE. Thank you, Mr. Chairman.

Thank you all, witnesses, for being here, for your testimony, and for, as the chairman said, keeping that testimony under 5 minutes. It may be a world record, I don't know. I hope somebody recorded it.

I was very fascinated by the testimony, particularly of the Navy and the Air Force, on STEM. You have several pages, Admiral, in your testimony. And, Dr. Walker, you mentioned it. I actually don't know anybody who is opposed to more science, technology, engineering, and mathematics education. Mr. Langevin missed it.

Last year, I was invited to speak to a group of chamber folks in Rochester, Minnesota. They were exploring what the chamber could do about STEM, and so they wanted to know—they wanted me to come down and talk about what the Federal Government was doing about it. And knowing I had to give that speech, I actually looked it up—actually, my staff did. And it turns out that, at that time last summer, there were 209 Federal STEM programs—209. And I don't know if that included Iridescent, Sea Perch,

FIRST [For Inspiration and Recognition of Science and Technology] Robotics, Youth Exploring Science, and the rest of them.

And I see, Admiral, that ONR was tasked with coordinating Naval STEM educational and outreach activities. And apparently, the ONR Naval STEM Coordination Office "provides a cohesive approach to STEM education and outreach across the service laboratories and warfare centers."

Dr. Walker, you have something called Bright Horizons.

What I am getting at and what is my question—and I am just sort of focusing on you two—is, how coordinated are you? I mean, it does seem to me that 209 may be enough, in terms of numbers of programs. And you are involved in them at the kindergarten level.

Gosh, I hope you have a lot of people and a lot of money to do this or at least that you are, in fact, coordinated and know what those other 208 programs are, so that we can make sure we are getting a return.

Admiral, tell us how that is working.

Admiral KLUNDER. Yes, sir. The timing of your question is perfect, sir, because just this morning I had coffee with a large, large room of exactly those individuals, to try and coordinate those efforts. I think everyone, and certainly from the Navy and Marine Corps, we value STEM. We feel that everyone has been very excited about it.

But what we are trying to do, in that exact point, sir, about coordinating the efforts and really true collaboration so we are not duplicating efforts, now what we are trying to do is—and we had this very healthy talk this morning—we have tried to move to a next level, a phase two of the effort. And I don't mean from funding, necessarily. I mean from, have we truly identified those events, those project-based learning—not daylong events but maybe it is a 2- or 3-day-long event, trying to determine where do we get the best return, the best connective tissue that leads us into an actual person, young person, entering a STEM kind of career path for the future.

I am here, frankly, as I always would, sir, to tell you that the initial phase of this was a lot of excitement, a lot of movement, a lot of momentum, but, truly, we haven't—the collective group hasn't been able to identify yet where were we on a return. Now we are starting to see that. We are starting to look at, were the internships increased? Were the direct entry in the Navy and Marine Corps with a STEM background increased? Were our undergraduates going to a graduate program that may service not only just a Navy and Marine Corps laboratory but also my colleagues' laboratories but also just the Nation as a whole?

And that is what we are trying to get right now for not only the Secretary of the Navy but working with my colleagues in the Air Force, sir.

Mr. KLINE. Thank you. So this meeting today included just Navy-related, or did the Air Force folks come in?

Admiral KLUNDER. We had a number across not just Navy and Marine Corps disciplines but also a number of those civilian organizations you just described, sir.

Mr. KLINE. Well, that is good to hear. And I think it is important that you do that. I hate to see us putting the scarce resources of people, as we are cutting them back, the DDR&E [Deputy Director for Research and Engineering] or the Assistant Secretary—so it has already cut back staff. And yet we have people with great excitement and great goodwill running around trying to help in the STEM area.

And I do think that 210, 211, 212, 213, 214, 215 may be just a tad more than we need. I would a whole lot rather see them coordinated and get some return for that investment. And I appreciate your effort there.

And I yield back.

Mr. THORNBERRY. Ms. Davis.

Mrs. DAVIS. Thank you, Mr. Chairman.

Thank you all for joining us.

Secretary, I wanted to ask you about your department's Office of Small Business Programs and the Rapid Innovation Programs that you have put the request out for, I guess, and you said four areas. And it sounds like you had a good response to that.

But I wonder if you could tell us a little bit more about, were you tasking generally just these four areas? And what do you have to help us out with these? If you got that many responses, you know, how are you dealing with that?

One of the things that I bet I share with all of my colleagues is a lot of frustration on the part of small-business developers, that it is very hard for them to get through the morass of—getting attention, obviously, when they have something significant.

Could you just talk a little bit more about that? And what do you expect to happen as a result of this?

Secretary LEMNIOS. Representative Davis, that is the—the connection that we are building and strengthening with the small-business community is absolutely essential in driving innovative concepts from the private sector into the Department's key capabilities. It is absolutely essential. The timelines, industry gets it. The small-business communities are ways to drive new concepts that just simply won't arrive out of long-term procurements.

This committee understands that. Congress passed the Rapid Innovation Fund, which we are acting on now. We issued four—the Department issued four solicitations: one from each of the services and then one that is an OSD solicitation that includes the fourth estate, it includes SOCOM [U.S. Special Operations Command], the Small Business Innovative Research Program, I think DARPA was included in that one, and MDA [Missile Defense Agency].

So that was a broad reach asking the small-business community to come back with two focused efforts. One were your ideas that would, within 2 years and within a $3 million cap, provide solutions for our joint urgent operational needs—that is, those solutions that could be immediately transitioned to the warfighter. And then second was those ideas that would have significant impact to our acquisition programs, that would tie directly to an acquisition program.

We are still in source selection, but what I can tell you is that we received as a result of those four solicitations about 3,500 responses. I am the source selection authority for one of those four

activities. The other services are working those through their channels.

But we did two things. We presented to industry a clear articulation of those challenges in an unclassified environment that sort of made it clear in layman's terms. And we listened to industry to try to shape the responses so that, in fact, we are able to make those connections not just for this solicitation but for the follow-on activities.

The way we will assess it will be not just is the money spent, did we actually get contracts on the record, but have we received the products as a result of that. You know, can I go to SOCOM, can I go to an operator and see the result of that small-business concept implemented in that operational capability—or to that acquisition program, that transition path.

This is an experiment. We are in the first phase. We have been working lockstep with the Hill to make sure that we are implementing it as you have directed us to.

Mrs. DAVIS. Is that $200 million going to enable you to do what you would like to do, in terms of really getting it——

Secretary LEMNIOS. Well, it is actually twice that. It is actually $400 million or $500 million. So it is a large amount of money.

Mrs. DAVIS. Oh, okay.

Secretary LEMNIOS. But we want to make sure that the first set of solicitations are executed synchronously and that we see the results. So the results of this will be evaluated as we go forward.

Mrs. DAVIS. Okay. Thank you. I appreciate that. If you come across a situation where perhaps our larger companies are looking at those, as well—and they certainly have that opportunity to do that. But I think when you talk about pushing things back to OSD, what worries me a little bit is that some of the larger companies that we have all been used to working with over the years, you know, sometimes ace out, quite honestly, some of the smaller companies that have the greatest opportunity for innovation.

Secretary LEMNIOS. I will just say as a follow-up, the large companies are watching carefully who is responding, and I think there will be connections made. My sense is that, as we move forward, I think we will see a change in the way that works.

Mrs. DAVIS. Great. Okay. Thank you very much. I appreciate that.

If I could very quickly, Dr. Gabriel, how are you connecting with so much of the research on PTSD [post-traumatic stress disorder] that is ongoing through the veterans community and, certainly, our universities and other research entities?

Dr. GABRIEL. Well, ma'am, it also is going to be responsive to your previous question about small business. Because, in my oral testimony, I mentioned the wristwatch-sized Blast Gauge device. This was a device that was designed, developed, and produced by a small business, actually, less than a year, less than a million dollars, and informed by the fundamental neuroscience work that has gone on in a previous program at DARPA to understand the correlation between blast exposure, in particular overpressure, and to PTSD and TBI.

The program, in partnership with the Army, we fielded an entire Second Brigade, Fourth Infantry Division throughout their entire

deployment last year, from August to actually just a little bit—a few weeks ago. The entire brigade had—every warfighter had three of these. I would be happy to pass it around. These are the Blast Gauges. This was developed, four iterations, very quickly, with the speed and capability of the small business to deliver those products.

It started out at $85 a unit, which for the full deployment was $1.6 million. And now, because of the innovation and speed of execution of the small company and the learnings they got from the manufacturing, they are able to do an entire brigade for $540,000.

So I think it is vital to pull small businesses in, not just through SBIR [Small Business Innovation Research] programs but actually to couple them to the core programs of each of the agencies.

Mr. THORNBERRY. Mr. West.

Mr. WEST. Thank you, Mr. Chairman and Ranking Member.

And thanks to the panel for being here. And it was good seeing you down at the AUSA [Association of the United States Army] Winter Symposium.

One of the things I believe, our best military technology is our human technology, and I think our smartest weapon that we have are the men and women in uniform. And, of course, with that being said, when you look at the budget cuts that we are going to have, when you look at about 129,000 of our men and women in uniform we are going to send away, my first question is, what are we doing from a science and technology perspective to fill that gap that we are going to be losing, with those men and women, for us to still be able to be successful on the battlefield? That is my first question.

And then the second question is, you know, what are the key and critical programs, the top one or two programs that each and every one of you are looking at? But then also going back to what we talked about a little earlier, how are we looking to develop common operating platforms?

You know, when I was at the AUSA Winter Symposium, I saw the unmanned ground vehicles. I know we have unmanned aerial vehicles. I know we are working to unman sea vehicles. How do we get all of these unmanned systems on the same operating platform so we don't create such an incredible burden in the research and development systems and also in the logistical supply systems?

So those are my two questions.

Secretary LEMNIOS. Representative West, let me start from a Department perspective. Absolutely, it is the case that when I visit men and women in uniform in the field, it is the warfighter that makes the difference. I was at Camp Roberts 6 months ago, and, you know, I saw training books, I saw training manuals, but I saw the real work being done by soldiers that were able to innovate concepts that were never part of any training manual, but they just knew how to make things happen. And that is absolutely critical.

On the way we leverage—the way we use science and technology to leverage the effectiveness of the warfighter, there are two specific examples that I will give. The other panelists may have others.

The first is, in theater, clearly, one of the bottlenecks, manpower bottlenecks, is in the processing, exploitation, and dissemination

cells that are taking enormous data feeds and translating them to operational decisions. And if you visit—and you were—you understand this well. It is an environment where tempo matters, where consequence of error is enormous, where the data is ambiguous. In some cases, it is missing; in some cases, it is just plain wrong and you have to sort of go through this. And we have programs across the Department that are looking at ways to integrate those data fields in ways that provide much better fidelity, much better responsiveness.

In the area of common operating picture, we have a major initiative with the Pacific Command that we call Cloud Break. It is an environment where we are, in fact, building across the Department an integration environment for a common operating picture. It is a testbed that allows small businesses and others to come in, put their algorithms in a joint information operations center where the combatant command actually gets the residual benefit of those efforts, and we get to see how these things trade one against another.

I think, at the end of the day, S&T in many of these areas has the opportunity—and we have seen it—to drive the effectiveness of the warfighter by reducing the burden, the work burden, and improving fidelity of the operational picture. Giving the community access to training environments is one way to do that.

Mr. WEST. Thanks.

Dr. FREEMAN. Yeah, let me make a couple of comments.

You know, the first thing is, the operational capability of unmanned systems is one of the things that we really want to capitalize. We have seen a lot, and particularly, you know, in the UAVs, big proliferation of UAVs, big utility, big payoff for everybody on using those systems at all the different echelons.

But one of the things we have in the Army is that, as I mentioned in my testimony, the issue that if you indeed are going to supplement and/or assist soldiers, small units, you know, warfighters, then there has to be an issue, particularly when there are things on the ground and you are operating together in relatively close proximity or you are counting on those systems to be there and not to break down and to do the things you want, that is where the technology really needs to go—the trust in those systems.

And we need to be able to demonstrate to our soldiers, to our warfighters, that particularly on the more complex things—I mean, flying in the air is great and it is very complex, but on the other hand there is not a lot of proximity there, as you have on ground systems.

So working these issues of how, if we are going to supplement and/or help with reduced numbers of people, how we are going to do that, we have to work technology-wise on developing the systems that people can trust. That really, really is important.

Mr. WEST. Okay.

Admiral KLUNDER. Yes, sir, thank you. And before I forget, you asked about top priorities, and I do want to emphasize—and we will get a chance to talk about cybersecurity later, and that is absolutely one of ours, both on the defensive and offensive side, as my DARPA colleague alluded.

But, certainly, the value of our people in the Navy and Marine Corps, that is without question. And where we think we may be able to leverage, again, technology, science—and this is both manned and unmanned streams. If we are going to have this huge amount of data that Mr. Lemnios described, we feel there that automation—but not just automation, the algorithms that we need to be able to do, with onboard processing that now allows not that 100 percent of throughput to go down to our limited manpower and pool of heroes, but now maybe it is really that 10 percent of vital critical information we need to throw down through the pipes. I would just offer, that is an area that we think we may be able to solve some of those manpower and personnel issues on shortages.

Certainly, in terms of an area that we think is very important—I think I am back to a point we talked about in being responsive to not only our COCOM [combatant command] and our fleet and force requirements, warfighter requirements, but just, frankly, our national security requirements. And that is, when we look at something, for instance, over in 5th Fleet, a year ago we may not have had as robust a mine warfare capability that we thought we needed with the current scenarios that we are being faced with. Today, I can tell you, due to responsive technology on some unmanned vehicles and the sensors that those carried, we think we now can confront the threat in a positive manner.

And I would like to offer that that was maybe a success that we saw within a year time frame where we broke through some barriers that you might normally see.

Mr. WEST. Yes, sir. Thanks.

Dr. WALKER. One of the areas I didn't mention where we have increased investment is autonomy. And we are actually leading that area for Mr. Lemnios as one of his seven priority areas.

Trust, you know, how do we trust these systems is critically important. Human machine interface is another area that we are working pretty hard to—or to, you know, lower the number of humans involved in that piece. And then the human performance piece, trying to do more data fusion, turning the data into knowledge so that we can have less folks sitting back looking at the data and interpreting it.

So those are the key areas we are trying to maintain and, actually, increase investment.

Dr. GABRIEL. So, sir, we believe data is a force multiplier. The challenge is to turn that data into actionable information.

And we are looking at that in two major ways. One is, we have looked across our ISR portfolio and shifted from about 70 percent sensor investment, 30 percent exploitation to more of a 50–50, more in the exploitation to turn that data into information. And also beginning to look at activities in big data, where there are emerging concepts, algorithms, and ideas coming from basic mathematics of how do you deal with lots and lots of data from big data.

Mr. WEST. Thank you very much.

Thank you, Mr. Chairman. I yield back.

Mr. THORNBERRY. Mr. Shuster.

Mr. SHUSTER. Thank you very much, Mr. Chairman.

Thank all of you for being here today.

I want to go back to the Rapid Innovation Fund briefly. I know Mr. Lemnios spoke about it, but I wonder if the other four panelists might briefly comment on the value you are seeing, if any at all, going through the process in terms of technology and the acquisition process.

So if you could just——

Dr. FREEMAN. Yeah, let me start, and then my colleagues can add.

You know, we in the Army use this Rapid Innovation Fund, and we focused our BAA [Broad Agency Announcement] on the top 10 challenges that I identified that were our warfighter challenges that we were looking to be able to solve. And we got a tremendous response back from small businesses and very nontraditional folks who wouldn't necessarily have responded to some of our other things. And we are really happy to do that.

One of the things we did is we evaluated all of the over 1,000 proposals that we got. I had a number of people in both the laboratories and then the people who were going to be running these what we call TECD [Technology Enabled Capabilities Demonstration] programs that focus on these challenges actually doing the evaluations. And, therefore, those technical program managers got to actually look through all of these ideas and these innovative thoughts and saw things that they would never, ever see before.

And so we really appreciate the opportunity to do this and then to link these up so that they get brought into our Army programs as integral parts of them, not as something separate, not as something, you know, totally different, but something that we are integrating and bringing those into our programs.

In addition, I have taken the list of innovations and the things that we got, responses we got back, and I am also looking at them for a second scrub to see if there are things in there that we may not be able to take directly to one of these TECDs because it was a little bit out of the timeline or not quite focused enough but are really good ideas and seeing if there are things that we should fund out of that out of our core program, as well.

So I really think this has been a big boon for the Army.

Mr. SHUSTER. Thank you.

And the rest of you have seen that kind of——

Admiral KLUNDER. Absolutely. And I won't duplicate the small-business side, but that is truly one of the core pieces of our RIF [Rapid Innovation Fund].

One offer is that, within that Rapid Innovation Fund, we have taken what we call our "tech solutions." That is where, within a year, we want to have—if a sailor or Marine has come to us and said, this is really a detriment to my performing my job out in the fleet or the force, can we turn that kind of innovation within a year? And that is where we have seen some real successes here.

It could be in things that we do even as simple as training, virtual training, that we want to get that quickly to a fleet sailor or Marine. Something also that we have seen innovative, in terms of a counter-piracy mission, for instance. We had young officers on a ship, going, "How am I going to interact?" Well, we have done that—again, within less than a year, we have been able to adapt that training through this kind of model, put it out to the Surface

Warfare Officer's School, and now they are able to understand that scenario much better.

Mr. SHUSTER. Okay.

Dr. WALKER. In our BAA, we put high importance on transition to programs of record. So we—actually, the product centers and the Air Logistics Centers are actually running the review process. So we are making sure that—and the small companies are finding that refreshing, because they actually have an opportunity to get into a program of record. So we are very positive on the program.

Mr. SHUSTER. Great.

Dr. GABRIEL. Sir, we have Rapid Innovation, in some sense, spread out throughout our programs. I talked to you about some of the activities going on with the Blast Gauge. That came from a small business. That was part of the core program that we had.

Mr. SHUSTER. Thank you.

And if I might, I know that as we went through the last authorization there was some concern about the process going through, was it fair and open competition.

I wonder, Mr. Lemnios, if you could comment on that.

Secretary LEMNIOS. Well, it is a fair and open competition. It was an open solicitation. The reason we rate it as a pilot—and we did this in concert with discussions that we have had with leadership here—is to make sure that, in fact, the effect that we put in the solicitation is the effect that we will see as a result of those contracts.

We have two very measurable effects here. One is, did the product of that contract actually end up in a warfighter's hands in 24 months, or did the product of that effort actually end up in an acquisition program in 24 months?

I think what we have done here—let me just take a minute—I think what we have done here is, we are opening a new dialogue with the private sector exactly along those lines of driving innovation in the small business and larger community. Our defensetechnologymarketplace.mil was put online to show the small-business community and the industrial base where our focus is. And we have asked for their feedback on where their IRAD [internal research and development] is. And so we are trying to build that engagement to drive innovation.

Mr. SHUSTER. Well, thank you. I think that helps us when we go through the next reauthorization. Because, again, I know on the other side of the Capitol there were some concerns about the open, fair process, so I appreciate your comments on that.

And thank you. I yield back.

Mr. THORNBERRY. Thank you. And I appreciate the work of the gentleman on his panel related to this very area. Thank you.

Mr. Gibson.

Mr. GIBSON. Well, thanks, Mr. Chairman.

I appreciate the panelists being here today.

Dr. Gabriel, with regard to the Focus Center Research Program, from my looking at it, it appears to be a pretty effective public-private partnership, particularly your work with the Semiconductor Research Corporation, $13 million invested and $18 million from the private side.

But I am curious to know your assessment and then, beyond that, what your vision is, looking at this budget, what priorities you have given for that.

Thanks.

Dr. GABRIEL. So, sir, thank you. You are absolutely right. I think, from our perspective, this is an area that we see as beneficial in a number of ways.

One, as you pointed out, every dollar of Federal funding is matched by a factor of one and a half to one. So for every dollar we put in, the industry consortium puts in one and a half dollars.

It does a number of things. It advances the semiconductor technology in ways that are beneficial to the industry at large. It has structured IP [intellectual property] relationships with universities that are beneficial to the university as well as industry. And it has been a tremendous accelerator of training and education for the next generation of scientists and engineers in the semiconductor industry.

Mr. GIBSON. And looking forward, priorities? Guidance? Anything that we should be looking for in the coming year and beyond?

Dr. GABRIEL. The industry representatives, the governing council that represents the industry members, they are in the midst of putting together their recommendations for how they would like to see the program evolve in the next phase, or in the next 3 years, if you will, of their anticipation.

And we will be having discussions with them over the next few months. We expect them to be articulating the type of technology areas they want to focus on as well as some of the activities and structures of the sorts of research they would like to support.

Mr. GIBSON. Well, very well. And I look forward to monitoring that. And I am certainly very proud of the work that our area is doing on this score. And I want to thank all the panelists again.

I yield back, Mr. Chairman.

Mr. THORNBERRY. Mr. Franks.

Mr. FRANKS. Well, thank you, Mr. Chairman.

I know the other committee members have sort of borne in the heat of the day here and I showed up at the last minute. I don't know if you can believe this, there is actually—I had a conflict. I haven't learned to bi-locate yet. And it never happens to me, but this time it did.

Thank you all for being here. Thank you for being sort of that invisible front line of freedom for all of us. We know that the work that you do in the technology advances and scientific advances are absolutely vital to the cause of freedom, and we are grateful.

I am going to do something I usually don't do. I am going to kind of let whichever one of you think would be the best one to respond to this question. And it is a question; it is not a leading narrative here. I want to genuinely know your perspective.

Reports show that domestic military installations receive 99 percent of their electricity from the civilian power grid. Furthermore, numerous studies have concluded that our civilian power grid could be critically vulnerable to both manmade and naturally occurring electromagnetic pulse, in this case either EMP [electromagnetic pulse] or GMD [Geospace Magnetospheric Dynamics].

One of your roles is to develop technology enhancements and processes to rapidly transition critical technologies to our national security force.

First, let me just ask the obvious question. Do you assess the civilian power grid to be vulnerable to both natural and manmade EMP? Does anyone assess it that way?

Dr. FREEMAN. I am going to take a little bit of a stab.

A number of years ago, I was on a defense board where we were looking at those things, and I interacted a lot with our Defense Science Board and those folks. And, you know, the answer to that question from the perspective of a lot of different folks was, yeah, we have issues there, and we have to look at those, and we seriously have to understand that.

In the Army, in particular, because we do have an awful lot of installations, we have an awful lot of bases that we look at, I work very closely and the folks in my office, and across the laboratory system in the Army, work very closely with the installations folks as we assess what our vulnerabilities are to power and energy issues. And one of the things that we are trying to do is actually set up the ability for our various bases and our various installations to be more energy self-sufficient, more energy-secure, and to have the ability not only to be more efficient and effective but also to be safe and not vulnerable.

It is a part of what we are actually looking at. And the science and technology community has a part to play there, and we are, in the Army at least, playing that part.

Mr. FRANKS. Well, that is a good answer. I have worked with some of the bases in our own state to that end, to that exact end.

Are you aware of some of the technologies that may be available today to mitigate the threat against the civilian grid? Has anybody—please.

Secretary LEMNIOS. So we have certainly looked at the risk assessment and the threat assessments, but they really are base-specific. There is a set of core technologies that need to be layered, and the threats need to be identified by a geographic area. And I am happy to sit down with you under a different environment and have that discussion.

Mr. FRANKS. Well, there was some technology that I learned about here recently, because this has been something that has been a concern of ours on the Armed Services Committee since we heard the EMP Commission report some years ago. And the neutral phase blockers ought to be something to be considered, because the cost is minimal, it allows the grid to run at a higher efficiency, it pays for itself. It is an incredible thing to look at.

So if you consider this a threat, is there a timeline available that portrays when the civilian power grid could, in your mind, be adequately protected against EMP? Or how serious is the situation now, and when do you think—what is being done to protect it, and when do you think you might have it where we would have some level of confidence?

Secretary LEMNIOS. Representative, I am not—I don't think any of us are prepared today to give you a calendar date as to when that is going to occur or what those risks are.

I will simply tell you, as I have looked at risk assessments, not only in that domain but others, there are very few silver bullets that allow you to sort of take the risk from a very high level to a low level.

What we do in most cases—in fact, in all of the ones that I have been involved in—is pull a red team together to do not only a threat assessment, but how would you, in fact, compromise a particular target. I will give you specific example. In cyber, a lot of the DARPA work is informed by red teams that actually look at measures and countermeasures. Our electronic warfare strategy is informed by red-team, blue-team assessments.

And so, on this particular one, I have taken a note, and I am happy to come back and chat with you.

Mr. FRANKS. I appreciate that.

Mr. Chairman, I will yield back here, just with the thought that, if this is as serious as some of these reports that we are getting indicate, then it seems to me it is something that we should all understand really where we are on it and what our plan is.

Thank you.

Mr. THORNBERRY. I thank the gentleman.

Mr. Langevin.

Mr. LANGEVIN. Thank you, Mr. Chairman.

If I could, Secretary Lemnios, the Weapons Systems Acquisition Reform Act of 2009 basically created two new offices charged with improving key areas of our acquisition process: the Director for Developmental Test and Director for Systems Engineering.

So, Secretary, I believe that both of these offices report to you. Almost 3 years later, what impact are those offices making? And are they helping, or did they just create another layer of useless bureaucracy?

Secretary LEMNIOS. Representative Langevin, those offices were created—were passed unanimously by both the House and the Senate, signed by the President earlier in 2009.

We stood up the offices to do two things: to, first, reduce the risk of operational testing, to really identify those operational issues well ahead of the final acceptance of weapon systems and also, much earlier in the process, pre-Milestone B, well ahead of the final acquisition, to really understand the system risk of both the technology and the architectures that are used in our systems.

We have a very comprehensive report that is coming to the Hill that outlines all of that. Our annual report is actually—I think it is due in a few weeks, and you will see the compilation of that.

But the end result of all this is that those two offices are engaged in every Defense Acquisition Board. They are asking the hard questions. They are asking the program managers to come back with evidence that we understand the risk, we understand the cost structure, we understand the time latency of our programs. And you will see that in the annual report.

Mr. LANGEVIN. Very good. I look forward to reading that report.

Admiral, if I could turn to you. Admiral, how do you plan on continuing to execute both the Solid State and the Free Electron Laser development programs? And where are your current challenges in those programs?

Admiral KLUNDER. Thank you, sir. It is nice that we are all here together today.

Certainly, on Solid State Laser, I will describe that first. Working with my colleagues across the services and with DARPA, we truly feel that in the last few years that technology has become much more mature, something that is achievable in terms of helping our warfighters out in the field.

I do want to offer that, from a Naval standpoint, there are obvious challenges to us in the maritime domain that affect things like lasers. Being able to have a beam director that can really focus down through the maritime kind of environment and atmosphere is a challenge. But we are looking at it, and we are teaming with my colleagues here across the table.

I do offer to you that, on the Free Electron Laser, we still see huge value in that. But we are also realistic, and working with your staff also, to realize that some of the technologies there still have a ways to go, frankly. There are some things on injector technology, some of the high-capacitor technology that we know are not in that, kind of, 2-year arm. It is more like maybe out here in a 10-year arm, potentially, that we are looking at.

I do want to also offer that, in terms of integration to a Navy or Marine Corps kind of asset, that we also have to look at certainly the footprint aspects to a Free Electron Laser. And that is another challenge that we are looking at, sir.

Mr. LANGEVIN. Thank you.

If we could go back to the issue of cyber. And to the panel, what do we need to change to ensure that we are better able to identify and mitigate risks in cyber domain? I know I asked that question earlier and time ran out, but I would like to come back to that and ask the panel to comment.

Secretary LEMNIOS. Representative Langevin, let me start.

Again, the cyber S&T area was one of our priorities, and it is one that we will be building for many years. This area actually very closely follows the work that we have seen and developed in electronic warfare. There are measures, and there are countermeasures. In the electronic warfare domain, those measures and countermeasures are measured in terms of maybe days, maybe weeks, maybe months. In cyber, they are measured in terms of minutes and hours.

So there is a challenge of both understanding the cyber threat and responding to it quickly, and building tools that allow us to both defend and operate in an environment that is greatly changing.

The focus of the Department's effort this year has been in building a common operating picture so that we understand those networks and we start building the measurements and the test campaign to understand, in fact, how we can use our S&T efforts and transition them.

Going forward, I suspect that you will see in the coming years ways to integrate a larger number of efforts across our networks. And that is going on right now in the services and certainly at DARPA, in terms of new concepts that are being developed.

We have brought the Department together. The Department spend in cyber across the budget is about $3.4 billion. In the S&T

area, it is between $600 million and $800 million a year. It is one of our focused efforts. It is one that has received a lot of attention. In fact, we plussed that up from last year in order to drive innovation into this area.

Mr. LANGEVIN. Thank you, Secretary.

Others on the panel?

Dr. WALKER. Sure.

We are in the midst, in the Air Force, of a study, Cyber Vision 2025, led by our Air Force chief scientist, Dr. Maybury. I am his mission support lead, which essentially means trying to take a look at how we do responsive cyber acquisition.

But what you hit on earlier is, how do we develop the next cyber warriors, so to speak, because I think the people element to cyber is just as important as some of the other stuff. And one of the things we are finding is—or one of the things we are looking at is, how can we work with our undergraduate institutions—the Air Force Academy, for sure, but even civilian undergraduate institutions—to get more of a cyber element into the computer science and computer engineering curriculum? We have been working with Syracuse University—our Rome Laboratory has been working with Syracuse University to do just that over the last year. And we are working with a couple other universities, but trying to get a more technical, cyber-oriented curriculum.

Working with some of our civilian institutions I think is going to be important to produce people that can think cyber and come into the services and help us.

Admiral KLUNDER. Sir, to kind of trump Steve's comments just a second ago about the young people, I offer to you that we feel—as we have teamed up on the STEM effort that Representative Kline alluded to, we absolutely are committed to that kind of focus area also within our STEM training.

I would use as an example my sophomore in college, my son. And I talked to him, I said, what are you going to take for an elective this year, son, in this semester? And he said, well, you know, Dad, there is this fantastic cyber expert that is coming in for one semester. And I know that is a selfish plug at the Naval Academy, but that is exactly what we have tried to do—bring in experts from the field. Because, as I mentioned before, sir, cyber isn't a traditional kind of warfare domain that you can take 10 years for an acquisition program to address. Those technologies flip every year, every 2 years.

And if we can't stay responsive, not only with our training of the people but also with our urgent operational fulfillment of those warfighter needs—and that is the other aspect quickly I would offer: that we have found great benefit, not only working with my colleagues across the table but at the other agencies in this town, in connecting right up front, collaboratively. If there is a warfighter, a COCOM urgent operational need, a JUON [joint urgent operational need], that we need to address now for national security reasons, frankly, we have been able to team quickly and kind of break down some of those more traditional acquisition barriers and move in more of a responsive, get-it-out-there kind of need.

And I think we have been successful. We know there are always challenges. I am not trying to say we are always looking in front of the target. But we think that is a way we can address that in a little more responsive way, sir.

Mr. LANGEVIN. And that applies to the people, too? You are making an effort to identify those people that may not be necessarily assigned to the cyber domain, that field and that is their, you know, their day job, but something that they have skills and that could be utilized?

Admiral KLUNDER. Absolutely. And we don't always necessarily have to look for a person that is in a computer science major, necessarily. We want to keep their depth of knowledge through electives, through any kind of acclimation through the cyber domain because we think—frankly, you might even eventually have a political science major that might want to get some kind of cyber expertise, and we could bring them into this kind of a future career path.

Mr. LANGEVIN. Thank you.

Dr. FREEMAN. And let me just take a little slightly different slant. And it kind of goes back to something Ken said.

You know, we recognize, certainly, that we have a need to protect our networks but also our data and our equipment from this ubiquitous threat. And, you know, that is something that—it isn't just about computers by themselves. It is by, you know, all the things that we have.

And I came out of the nuclear community, you know, many, many, many, many years ago. And one of the things that I did as a young scientist or engineer is I was taught that the first thing that you do if you are a designer is that you design something in your mind and then you have people who try to attack it and then you have people who try to solve that as a designer, so that you build in the resilience and you build into your design the ability to make it hard for those people who want to get into the systems to actually do that harm.

And so one of the things, in addition to all the things that everybody else has said, is we have to train our scientists and engineers—not just our computer scientists and engineers, but all of our design folks to wear what we used to call the black hat, the white hat, and the gray hat, to go figure out how to do better designs of systems and to think through not just designing for success in performing something but also thinking about how it might be attacked. And that includes protecting the data, protecting the equipment, knowing where things are. I mean, all of that stuff is going to be really important. And I really feel very strongly that we need to get our scientists and engineers across the board interested in that.

Mr. LANGEVIN. Yeah. I agree. The Internet, when it was built, was never built with security in mind, and I guess unfortunately. But we are trying to retrofit now, as we do it. But if we can think as we are designing new systems, ahead of time thinking about security, I think we will be better off for it.

With that——

Mr. THORNBERRY. Will the gentleman yield?

Mr. LANGEVIN. I am——

Mr. THORNBERRY. Well, I just wanted to follow up. I hate to break this to you. We are actually going to have to start training the lawyers to understand some of this stuff. And I think the point you all are making is one that I have come to understand as we deal with this issue. It is not enough for just computer science people to understand it. We are going to have to have, you know, "Cyber for Dummies," because it will permeate everything that we deal with.

And, you know, this is not really you all's issue, but I do think we have some responsibility to push that. You are on to something, I think, that is exactly right.

I didn't mean to——

Mr. LANGEVIN. No, I thank you, Chairman, and I agree with your comments. And, with that, I yield back.

Mr. THORNBERRY. Thank you.

Secretary LEMNIOS. Mr. Chairman, if I might just add one point? You are spot on, that it actually is part of our responsibility to broaden that tech base.

To connect the dots, and sort of one last point in the sentence, and that is, we have an opportunity to train new students through our STEM initiatives. This summer, we have 670 students that we are sponsoring through our SMART [Science, Mathematics and Research for Transformation] Program that will be placed in our Department's laboratories. So that is a shaping function. Those students are being selected. In fact, we have 2,800 applicants for the next round of admission into that program. It is a year of—it is a year of service for every year of college tuition that we provide. And we can actually shape, and we have shaped, the posture of that class that we accept into technical fields, which might include cybersecurity, might include cyber policy, certainly includes advanced technology in those areas that we see are the growing ones for the Department. And that is our feedstock.

And so this STEM future-needs-of-the-Department shaping function actually does close and we have a way to do it. You have given us the authorities to do this. The 219 authorities allow us to extend that, and we are certainly working across the laboratories with those authorities. And we are working to make those connections.

Mr. THORNBERRY. Mr. Secretary, while we are on the subject of cyber, let me ask the annual "how do you deconflict" question. Because any time there is something that is the hot issue, all sorts of stuff gets that label. Yeah, we have all sorts of things that are being labeled with "cyber" these days, not just in S&T, obviously, but throughout the Department.

So reassure us that you are looking at all of these cyber initiatives across the services, across the different DOD agencies of various kinds, and that there is some method to this madness.

Secretary LEMNIOS. So, Representative Thornberry, the Senate 933 report, which we are finishing up, outlines the Department's strategy for cyber integration. It includes the Cyber Integration Management Board. That is sort of the policy piece within the Department to do exactly as you are asking—as you are suggesting.

But I will also tell you that, as part of the review that I conducted last fall with a small team, you know, I went and I visited the laboratories, I talked to the researchers, spent time at DARPA,

spent time at each of the services. One thing that impressed me, we have a remarkable set of talent. We have a good set of programs. They are a balanced set of programs, everything from those things that might make you a little itchy to those things that are going to be operationally relevant in short order because they are being built with deliberate timelines. And we have to have that balance, we have to have flexibility.

The integration effort across the Department will be through the Cyber Integration Management Board that the Department is standing up to do exactly as you are suggesting.

Mr. THORNBERRY. Let me shift topics for just a second. Another area that this subcommittee has been particularly interested in, kind of related to our other responsibilities, is irregular warfare. The country has learned a lot, sometimes painfully, over the last 10 years about irregular warfare. Obviously, it goes back much further than that.

But I am just curious. There is some feeling that, as things wind down in Afghanistan, there will be a temptation to move on to other kinds of fights. And from an S&T perspective, is there anything that just pops into your brain that is going on in your fields that would be related to irregular warfare to help make sure that we don't have to relearn lessons again someday in the future that have been bought at a pretty high price over the last 10 years?

Secretary LEMNIOS. Representative Thornberry, I am going to go back to some comments that Ken Gabriel made regarding the cost point for electronic warfare. And, in many ways, I look at that as an analogy to—a real analogy to irregular warfare in a different domain.

Mr. THORNBERRY. Yeah.

Secretary LEMNIOS. So while we are certainly drawing down overseas contingency operations and we will be moving that to a different point, the urgency—irregular warfare is really about urgency and it is about rapid transition. Through the last 10 years of war, the Department has put in place a fast lane to get concepts quickly to theater. We have demonstrated that with MRAPs [Mine-Resistant Ambush-Protected vehicles] and body armor and other systems that are being fielded on timelines that are unimaginable to the standard acquisition process, that have been remarkably effective, that save lives every day.

The question then becomes, what does that actually look like in a theater where the technology tempo is changing month to month? And that is actually what is driving our connection with the communities that we are trying to build these channels with—with innovative small-business communities, with technology transition concepts. A real push in cyber to build app store models for the way we operate systems that sort of mimic what we are seeing in the private sector, where you can go to any company and buy your next product in a year's time and you know that you have doubled the capacity of that product on the same cost point.

So I think what you will see is irregular warfare is really a moniker for rapid fielding of new technologies. And everyone here is on that—you know, we are all on that. You know, we are pushing in the S&T area, as I mentioned, the ones that are service-specific,

the ones that are crosscuts, and really trying to drive new models with the private sector.

Dr. FREEMAN. If I can kind of go back, if you look at the 24 challenges that we have laid out in the Army as saying that they are our highest S&T priorities that we are looking at, and they are all focused on the soldier and the small unit and all of the things that they have had to do but we also believe they are going to continue to have to do around the world, regardless of where we are.

I think we actually kind of get at, at least on the Army side particularly, by focusing on those things, you know, for a major portion of our program, not losing those lessons learned. We will still have COPs [command observation posts] and FOBs [forward operating bases]. We will still have the issues of getting technology out to far distant people and people who are doing all of those different kinds of jobs that are going to continue. Whether you are in the Asia Pacific or whether you are doing anything else, we know that that is going to be there. And I think what we are doing is trying to focus at the tip of the spear. I think that will help.

Mr. THORNBERRY. That is a good point. We don't know where we will be, but we most likely will be someplace remote, and that is a whole set of challenges.

Admiral KLUNDER. Chairman Thornberry, this is a selfish plug for my colleague behind me in the Marine Corps, but I need to give him a quick shout-out. Our whole S&T strategic plan was catered and focused to that anti-access/area-denial, which, again, needs be forward presence and be a 9-1-1 kind of response and mentality. So that is something we are going to continue to do for the absolute foreseeable future.

One area, though, I will offer that we probably don't think about as much when we think about expeditionary irregular warfare, and it is back to that kind of information piece that we have talked to a little bit, not only just cyber, but I am talking about the agility to do that. And that is something we are looking at. It is not about residing in spectrums that only our threats know about and are very comfortable in. It is about looking at ways to be agile around those spectrums; that, again, we can still be irregular and expeditionary, that they can actually track us in those very defined spectrums that we are all used to playing in, if that made sense, and from an information dominance cyber standpoint, sir.

Mr. THORNBERRY. Thank you.

Dr. WALKER. And we in the Air Force over the last 10 years have gotten really good at unmanned ISR but in environments where we control the air. And so, as we move into A2/AD and nonpermissive environments, how do we do that mission and how do those systems interact with our manned platforms is an area we are taking a hard look at.

Also, how we work with the Navy in an AirSea Battle construct. And it is not really irregular war, but it is a new concept that we are fleshing out. And, you know, one of the key technology areas there is electronic warfare, as has been mentioned. So how do we do more together in that space, as well as cyber, for that type of scenario.

Dr. GABRIEL. So, sir, I would take it back and say that irregular warfare is really about adaptability and your speed of response.

And that is the focus, as you have heard us talk about our Advanced Manufacturing Initiative—everything from ground combat vehicles to optical systems and reducing the time that it takes for us to design, develop, and test and field those sort of systems.

One additional layering that I would add in terms of what we have learned most recently over the past few years are from some of the activities that we had in theater—TFJ Dot [Task Force Joint DARPA Operational Trials], which we have described to you, everything from LIDAR [Laser Identification, Detection, and Ranging] to the Blast Gauges I talked about earlier. Those came about not only with a focus on time but a very tight coupling and integration of both the S&T folks as well as the operators, side-by-side, so that the development cycle times weren't lengthened by the back and forth ping-ponging but, rather, the fact that they were sitting right next to each other and quickly converging and iterating on a much better solution.

Mr. THORNBERRY. Mr. Secretary—I think it was you—you caught my attention with your comments about globalization of technology. Earlier this week, I was out in California at a cyber conference. And you walk around the floor, you see all these small businesses that, you know, just have, you know, it looks to me, pretty amazing stuff.

So I guess my question is, how—and it is really for any of you, I guess. But how do you, number one, know what is happening in technology in the world, particularly when so much occurs with small businesses that don't have the regular interaction with you?

And, secondly, somebody, one of the companies I met with, proudly told me their R&D budget was more than double DARPA's whole budget. You know, they seemed very proud of that. But part of the question is, how do you all leverage what the companies are doing? And, I mean, so you have the small businesses, you have big companies with massive budgets of R&D. How does all of that fit together as you all are moving ahead?

Secretary LEMNIOS. Well, first of all, money is not everything, but it does help. The global R&D budget, globally, is about $1.2 trillion. About a third of that is in Asia, about a third of that is in this country, and about a third of that is rest of world. But, round numbers, about $400 billion that U.S. companies spend in research and development.

Our budget request of $12 billion is focused on those particular areas where the Department either will drive new areas that we need to open or will sustain competence and leadership in areas that we, in fact, depend upon.

And as far as how do we find those ideas, you know, if you are an agency director and you have a budget, they sort of find you. I can't tell you how many proposals I get each week. I am not an agency director, but they seem to find me. And I encourage that. You know, we look for ideas that don't come from traditional sources. We have open solicitations.

We try to build a much stronger connection with industry. I mentioned the Defense Innovation Marketplace is one way to drive that discussion. We are building a very strong connection with industry's IRAD. What I actually want to do is help industry understand the Department's future needs so that they can shape their invest-

ments. You know, it is sort of like, let's partner on this and be smart about it. Industry is asking for that. The Rapid Innovation Fund is a piece of that. It is not all IRAD-centered, but it certainly leverages that.

So I think we are trying to build a much tighter connection with industry, having industry understand where the Department is going so that they can use their budgets accordingly.

At the end of the day, it is about people. So whether you have a budget twice the Department's budget or not, it is really about the people that have technical ideas. And I will again point back to Ken and the model that DARPA has. You know, they can rotate a good part of their portfolio because they can bring people in rapid sequence. You know, we actually across the Department are trying to build those threads, and that is critically important.

Mr. THORNBERRY. Yeah.

In a way, it gives DARPA an advantage, because you do rotate your people in so they have that freshness of knowledge about what private industry is doing, I guess.

Dr. GABRIEL. Absolutely right, sir. We rotate people in 3- to 5-year durations. That not only rotates in fresh ideas, fresh perspectives, new perspectives, but it also gives a sense of urgency to the people doing their job, right? They have a finite time to get it done.

But I think there are two other areas in which we are leveraging and understanding what is happening in the commercial marketplace and in industry. One is, 70 percent of our budget actually goes to industry—small business, medium-size, big-size. And often that is leveraging the investments that they are making, and are also areas that they are creating their next-generation capabilities and products. So that is ensuring that we are getting involved with them very early on with things that they are looking for in terms of future capabilities.

And, finally, I would say that we are constantly looking at our own internal business processes so that we are opening the aperture as wide as we can to bring in a greater diversity and number of folks to do business. I mentioned Cyber Fast Track in my oral testimony—it is in the written—where we have consciously worked hard to tap into a segment of the cyber community, where, as I shared with you, 84 percent of the people that are now working with us had never done business with the government before.

Mr. THORNBERRY. Thank you.

Dr. FREEMAN. And let me go back, if I may, just to one point that is, sort of, the outside this country; how do we know what is going on outside this country?

One of the things that we have in the Army, and I think other people have something similar, but we have what we call ITCs, which are International Technology Centers. And we have people who are scientists and engineers who are stationed in various places around the world in these centers whose job is to go out and look for what is going on out in those areas. We have somebody, you know, in Europe, somebody in Africa. We have all different places in Asia, et cetera, et cetera, et cetera. So we are people who are looking for that. And they come back and they report back to us and to our scientists and engineers what they are finding out there that is pertinent to us.

Second of all, let me go back to the people. Those scientists and engineers in all of our laboratories go to conferences. And it is very important that we allow them to do that around the world, because that is one of the places—just like you saw things out in California, that is where our scientists and engineers see things that are different and bring that information back into our corporate laboratories and help us to understand how we are doing things either differently or where they are with respect to us with technology.

Mr. THORNBERRY. Yeah. And I know the Navy has a similar effort, because we have talked about it.

And I just think it is—there is so much moving so fast, it is an enormous challenge. So I appreciate what you all do.

I have one last question, and then anything else Mr. Langevin may have. I have been preparing for some remarks I will have to give later, looking back at one author's opinion about—well, actually, he surveys past revolutions in military affairs and talks about the technologies that will drive the next revolutions in military affairs.

I would be interested if you all disagree with any of these, if you think they are not that big a deal, or if there is a big thing that is left out: One is robotics; second is space; third is lasers and directed energy; fourth is cyber; fifth is nanotechnology; and sixth is biology, both, you know, improving our own soldiers and nefarious kinds of biology.

Does something jump into your mind that he left out there, as far as technologies that could drive the next revolution in military affairs?

Yeah, Dr. Gabriel.

Dr. GABRIEL. Yes, sir, if I may, I think one that is glaring in its absence is a hyperconnected, socially networked world. As you know, everyone is now connected. We talked in my oral testimony about hundreds of millions of people walking around with cell phones. But they are connected now, and they are connected in ways that was not possible even 10 years ago.

We did, as we shared with you before, a competition at the 40th anniversary of the building of the Internet where the competition was to find ten 8-foot-diameter red weather balloons situated somewhere in the lower 48 States. Those balloons were found in 8 hours and 52 minutes by socially networked, connected groups that had an incentive to find them. This was a $40,000 prize. Those ten 8-foot-diameter red weather balloons could not have been found with the assets—the traditional assets that we had.

So they are creating both opportunities and threats for us with this sort of capability.

Mr. THORNBERRY. And so, Arab Spring-like examples. Your point is that that whole phenomena is a whole field in and of itself. It is not just faster communication; it is a whole field in and of itself.

Dr. GABRIEL. Absolutely, sir. Not only for—imagine you set up a checkpoint, we set up a checkpoint somewhere, and within seconds everybody knows where it is, how many people are there because of that connectivity that is everywhere in the world. In Bangladesh, there are 30—out of 100 in the population, 30 have cell phones. Worldwide average is 64 per 100.

Mr. THORNBERRY. Interesting.

Dr. FREEMAN. I guess I would add one more, and it is more of the things that it could be good or it could be bad, and it is about power and energy. And if we do not—I mean, we really have to—I mean, and some of these things like nanotechnology and some of those other things are part of that, but a real focus on where and what we can do with power and energy is really, really something that I think can either be a game-changer or it can be a game-killer.

Mr. THORNBERRY. Yeah. No, that is a good point. It bothered me a little bit, one of you all mentioned reducing your investment on energy as a result of the budget cuts. And, yeah, I take your point. It will be central to anything we do in the future.

Anybody have anything else?

Mr. Langevin, do you have any other questions?

Mr. LANGEVIN. I thank the panel.

Mr. THORNBERRY. Yeah. Well, I do, too.

Thank you. Again, you all timed it just perfectly. Votes are about to start. And so, thank everybody for being here and for what you have done.

With that, the hearing is adjourned.

[Whereupon, at 4:55 p.m., the subcommittee was adjourned.]

A P P E N D I X

FEBRUARY 29, 2012

PREPARED STATEMENTS SUBMITTED FOR THE RECORD

FEBRUARY 29, 2012

Opening Statement of The Honorable Jim Langevin, Ranking Member, Subcommittee on Emerging Threats and Capabilities

Hearing on
Fiscal Year 2013 National Defense Authorization Budget Request for Department of Defense Science and Technology Programs

February 29, 2012

Thank you, Mr. Chairman, and thanks to all of our witnesses for appearing today.

Like all of us on this committee, I believe that much of our nation's military and economic strength lies in our ability to lead the world in innovation and that the defense science and technology enterprise continues to be a major contributor to that leadership.

I am pleased that the President's recently released defense strategic review recognizes this, and in light of necessary fiscal tightening, his FY13 budget request largely protects defense science and technology investments.

Portions of those funds are targeted for STEM education activities—a key investment in maintaining strong intellectual capital and technological advantage in this country.

I believe all of you, in your written testimony, noted to some extent your overall interest and concern towards fostering and maintaining a world-class scientific workforce.

I share that interest and strongly believe that the Department of Defense plays an important role in the entire STEM education pipeline—a pipeline of professionals that not only develops new and improved warfighting capabilities, but also prepares competent operators and maintainers of these game-changing technologies.

I look forward to hearing more from our witnesses on each of your efforts in this area.

I particularly want to applaud you, Admiral, for the Navy's commitment to double Naval STEM investments by FY15. I would also like to highlight ONR's recent recognition as a leader among industry and government in promoting workforce diversity and in developing strong partnerships with minority-serving institutions to advance STEM academic excellence throughout all sectors of our future workforce.

Much of the Department's basic research investment goes directly to universities to advance our understanding across a wide array of disciplines, building upon the critical investments at the K-12 level and producing benefits not only to our national security but also to the leadership of the United States in academic research and development.

I firmly believe that outreach to, and engagement with, our youth are the best investments we can make to ensure a technological edge in the future.

The researchers of today and the immediate future, however, face different challenges.

Dr. Freeman, I appreciate concerns you raised in your written testimony about our defense R&D facilities. These facilities provide needed capabilities for DOD with their uniquely skilled personnel and laboratory abilities, and their health is crucial for our overall R&D and acquisitions efforts.

Labs also are key to attracting the best and brightest researchers to solve difficult problems—but conversely, if not properly resourced, inadequate facilities and equipment can make it harder to attract and retain the personnel we need, let alone to stay ahead of our technological competitors.

During similar budget posture hearings, some of your Department colleagues responsible for big weapons procurement may talk about one system that alone could cost over 100 million dollars.

A hundred million in the S&T world could mean dozens of early-stage programs or demonstration programs.

I recognize that you can't go through your entire S&T portfolio in one hearing, but I would appreciate a brief comment on areas supporting directed energy and the development and tests of technologies supporting prompt global strike objectives.

Additionally, I believe this committee and frankly all of Congress would benefit from your oral statement on the implementation and early successes, if any, of the Rapid Innovation Program.

And lastly, but with special importance to myself and the Chairman, I want to take some time today to explore the critical and uniquely dynamic area of cybersecurity research and development. As we all know, the nation faces serious cybersecurity threats and vulnerabilities that cut across .mil and .com alike. I look forward to hearing about the Department's research investments and strategy to develop the tools and capabilities we will need to operate effectively and securely in the cyber domain in the future.

With that, I'd like to thank you all once again for appearing before us today, and I look forward to your opening statements and what is certain to be an interesting discussion.

Statement Testimony

The Honorable Zachary J. Lemnios

Assistant Secretary of Defense for Research and Engineering

Before the United States House of Representatives Committee on Armed Services, Subcommittee on Emerging Threats and Capabilities

2/29/2012

NOT FOR PUBLICATION UNTIL RELEASED BY THE COMMITTEE

Mr. Chairman, Ranking Member Smith, members of the committee, I am pleased to be here today on behalf of the dedicated men and women of the Department of Defense who discover, develop, engineer, and field the critical technologies that are the foundation for a secure future. I would like to thank the members of Congress for your continued support of the Department's science and technology (S&T) program and our broader research and engineering (R&E) enterprise[1]. Your steadfast support has allowed the Department to field technologically-based military capabilities that provide the capability edge upon which our Soldiers, Sailors, Airmen, Marines and civilians rely.

I am honored to be joined today by leaders of the Department's Science and Technology (S&T) organizations who will provide testimony in support of their individual programs - Dr. Marilyn Freeman from the Army, Rear Admiral Matthew Klunder from the Navy, Dr. Steven Walker from the Air Force, and Dr. Ken Gabriel from the Defense Advanced Research Projects Agency (DARPA). Their leadership has proven instrumental in ensuring our S&T investments provide compelling technology options and unmatched operational capabilities for the Department.

We testify today in support of the Fiscal Year 2013 President's budget request for DoD S&T; a request that has been thoughtfully prepared within context of challenging national fiscal environment. I can assure this committee we are all mindful of the budget pressures facing our Nation. We have made a collective commitment to ensure that the taxpayers' dollars provided to the Department's S&T enterprise are invested wisely with a laser-like focus on needed capabilities for our national security.

New Strategic Guidance

On January 5, 2012, the President released new strategic guidance for the Department of Defense[2]. The strategy builds upon developing partnerships and global alliances. It rebalances our global posture and presence to emphasize Asia-Pacific and the Middle East. The Guidance sets a new path for the Joint Force of the future[3]- a force will be smaller, leaner, agile, and flexible, and rely upon advanced technical capabilities for mission success. The guidance outlines ten primary missions for a 21st century defense, which the Joint Force must be prepared to execute. The Department's S&T budget request was structured in scope and content to support these missions.

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[1] Science and Technology (S&T) is defined as the sum of basic research (6.1), applied research (6.2) and advanced technology development (6.3). Research and Engineering is S&T plus Advanced Component Development and Prototyping (6.4). Both S&T and R&E are activities that occur before initiation of formal acquisition programs.

[2] Sustaining U.S. Global Leadership: Priorities for 21st Century Defense, January 2012

[3] Sustaining U.S. Global Leadership: Priorities for 21st Century Defense, January 2012 - cover letter from Secretary of Defense Leon Panetta,

FY 2013 President's Budget Request (PBR)

The FY 2013 Department-wide S&T budget request of $11.9 billion ($62 billion from FY 2013 - FY 2017) maintains a strong S&T posture. The FY 2013 PBR is above the FY 2011 enacted budget of $11.7 billion, and down modestly from the FY 2012 enacted budget of $12.2 billion. The FY 2013 S&T budget request:

- Maintains Basic Research at $2.1 billion - an investment that largely supports university based research;
- Funds the Defense Advanced Research Projects Agency at $2.8 billion to develop strategic concepts for the Department;
- Funds Counter Weapons of Mass Destruction S&T at $1.0 billion; and
- Maintains S&T funding in each of the Military Departments at approximately $2.0 billion.

In preparing the FY2013 S&T Budget for the PBR request, I led a comprehensive review of the Department's Research and Engineering program elements and projects. This review, coupled with the Department's Strategic Guidance, shape the scope and content of the S&T budget request.

The FY 13 PBR S&T investment rebalances and aligns content to support the Department's strategic guidance. For example, $700M was added across the Future Years Defense Program (FYDP) to enhance the Joint Forces' ability to operate across all domains. This funding is targeted to initiate an Air Force hypersonic cruise missile capability demonstration, accelerate the development of advanced electronic warfare (EW) concepts, accelerate technology development for the Long Range Anti-Ship Missile program, and launch technology development efforts in anti-jam precision guided munitions. Additional adjustments were made to increase funding in the Department's S&T priority areas of Cyber S&T, Electronic Warfare, Autonomy (Robotics), and Advanced Manufacturing by realigning funding in lower priority areas. The Department also increased investments in a next generation, high-efficiency turbine engine, the Adaptive Versatile Engine Technology (ADVENT), for an engineering and manufacturing decision in FY 2014.

The table below summarizes the Fiscal Year 2013 budget request.

Program ($Billions)	FY 2011 Enacted	FY 2012 Enacted	FY 2013 Request	FY12 – 13 Change
Basic Research (6.1)	**1.9**	**2.1**	**2.1**	**0.0**
Applied Research (6.2)	**4.4**	**4.7**	**4.5**	-0.2
Advanced Technical Development (6.3)	**5.4**	**5.4**	**5.3**	-0.1
S&T Total	**11.7**	**12.2**	**11.9**	-0.3

Today's testimony by the Department's S&T leadership provides additional detail on key strategic initiatives in the FY 2013 budget request. The testimony will also describe initiatives

underway to accelerate the transition of concepts into technologies that will be part of future acquisition programs.

S&T Priorities

In FY2010, we gathered over 200 scientists, engineers, operators and subject matter experts from across the Department and launched a comprehensive analysis of operational architectures, critical capabilities, and enabling technologies to support the Department's current and future missions. We took a broad look at cross-cutting areas that would have the greatest impact to the Department, even as the Department's New Strategic Guidance was being outlined.

That review resulted in the April 2011 announcement by Secretary Gates that the Department will consider seven science and technology areas as key priority areas. These priority areas are supported in the FY 2013 PBR 2013; these investments provide the technical foundation for important future capability options:

- **Cyber Science and Technology** – The focus of cyber S&T is on the development of technologies that enable system resiliency, agility, and mission effectiveness across the spectrum of joint operations. The research also addresses foundations of trust and development of new frameworks to more thoroughly assess cyber-security techniques.

- **Electronic Warfare / Electronic Protection (EW/EP)** – Pervasive advances in commercial and consumer electronics, challenge conventional U.S. electronic warfare capabilities. Investments in this area focus on new concepts and technology to protect systems and extend capabilities across the electro-magnetic spectrum.

- **Data-to-Decisions** – The Department relies upon the ability to analyze enormous data sets very quickly. Data-to-Decisions investments focus on investments in automated analysis techniques, text analytics, and user interface techniques to reduce the cycle-time and manpower requirements required for analysis of large data sets.

- **Engineered Resilient Systems** – The technically advanced systems our Joint Forces will need in the future must be adaptable to operate in dynamic, and sometimes unpredictable, environments. Research in Engineered Resilient Systems focuses on agile and cost-effective design, development, testing, manufacturing, and fielding of trusted, assured, easily- modified systems.

- **Counter Weapons of Mass Destruction (WMD)** – The Department is focused on crosscutting research in countering weapons of mass destruction, specifically directed at finding and tracking unsecured fissile material. Research focuses on the development of novel detectors and processing algorithms for increased detection capabilities.

- **Autonomy** – The Department's investments in this area are focused on developing systems that can operate in complex real-world environments. Such systems will augment or substitute for human operators, particularly in hazardous environments, and to conduct missions that are impractical or impossible for humans.

- **Human Systems** – This goal of Human Systems is to advance the Department's technology capabilities for development of system interfaces and for training of personnel to increase productivity and effectiveness. Training research focuses on realistic, adaptive, and interactive scenarios, and persistent, affordable integrated training. Personnel training research concentrates on human-machine teaming; intelligent, adaptive human aiding; and intuitive interaction.

The seven DoD S&T priorities represent an integrated effort by the Department to focus technical staff and budgetary resources on a set of primary topics important to the Joint Forces. For each priority S&T development roadmaps are being developed to focus near-term project investment portfolios and experimentation campaigns.

Basic Research

The Department's basic research program paves the way for our technological future – today's scientific discoveries provide the foundation for tomorrow's capabilities. Given the rise in global investments in research and development the U.S. cannot assume assured technological superiority - we must remain on the scientific cutting edge through adequate investment. The FY 2013 PBR of $2.1 billion maintains a strong basic research program. In fact, the PBR represents a 17.8 percent real growth in basic research funds since FY 2009. The President's long standing commitment to a strong DoD basic research program has yielded a number of world-class scientific breakthroughs. Among the remarkable achievements this past year,

- Air Force-sponsored researchers at Harvard University have succeeded in coaxing ultracold atoms trapped in an optical lattice to self-organize into a magnet, using only the minute perturbations resulting from quantum mechanics. The research, published in the journal Nature[4], is the first demonstration of such a "quantum magnet" in an optical lattice, opening new possibilities for quantum engineering of novel materials like high-temperature superconductors.

- In the area of novel engineered materials, Army funded scientists at the University of Maryland and the Joint Quantum Institute, working with scientists at the Army Research Laboratory, discovered and demonstrated methods for creating the first functional atom-based circuit[5]. This achievement is a crucial milestone in atom-based physics, or "atomtronics," that has the potential to go well beyond 20th century electronics, enabling breakthroughs in ultra-accurate gyroscopes and ultra-secure quantum encryption.

- The Navy's synthetic biology program has succeeded in developing multicellular computation using genetically programmed logic gates and chemical 'wiring'[6]. Ultimately it should be possible to encode more complex circuits in individual cells which, once linked by cell–cell communication 'wiring' may resemble logic blocks used in field-programmable gate arrays. This methodology can be used in the engineering of

[4] Nature **462**, 74-77 (5 November 2009) | doi:10.1038/nature08482; Received 20 July 2009; Accepted 3 September 2009 "A quantum gas microscope for detecting single atoms in a Hubbard-regime optical lattice"

[5] "First functional atomic circuit will enable revolutionary sensors"

[6] *Nature* **469**, 212–215 (13 January 2011) doi:10.1038/nature09565 "Robust multicellular computing using genetically encoded NOR gates and chemical 'wires'"

biological systems to perform increasingly complex functions, e.g., manufacture of fuels, pharmaceuticals, or as sense-and-respond devices.

- The Navy in collaboration with DARPA has co-funded work in Nitrogen-Polar Aluminum Gallium Nitride (AlGaN) High Electron Mobility Transistors (HEMT) which demonstrated for the highest frequency performance on record, at 272 GHz (fT) and 350 GHz (fmax)[7]. The research, conducted at UC Santa Barbara, is significant as this is emerging as the leading technology for solid state millimeter-wave RF amplifiers for Navy sensors, communication systems and electronic warfare.

The Defense Science Board (DSB) recently completed an assessment of the Department's basic research program[8] and found that the current DoD basic research program is very good, comparable to other basic research programs in the government and well-suited to DoD needs. The assessment characterized our basic research program managers as highly qualified, the program reviews plentiful, and coordination among researchers as excellent. The DSB recommendations focus primarily on the development of new business processes to ensure our future research talent pool and methods to meet the challenges of operating in an increasingly globalized research and development environment.

We have used the results of this assessment, the ASD(R&E) comprehensive review and extensive meetings with academia to identify emerging technologies that could form a basis for the next generation of dominant military capabilities in the next decade. Some examples are:

- ***Synthetic Biology*** involves modifying living cells (typically bacteria) to produce novel substances, such as bio-fuels, bio-sensors, improved vaccines, and high strength materials.

- ***Quantum Information Science*** uses quantum mechanics to perform otherwise intractable numerical calculations, provide ultra-secure communications and solution possibilities to certain important problems, and enable an ability to simulate exotic materials.

- ***Cognitive Neuroscience***, the study of how the brain functions, provides a deeper understanding of human learning and decision-making, which can lead to improvements of performance under stress and to cures to the effects of war trauma.

- ***Novel Engineered Materials*** encompasses superconductors, metamaterials, plasmonics, and spintronics, among other materials, that can provide fluid-repellant coatings, yield self-healing composites, improve energy efficiency, improve antennas and detectors, and greatly increase computational capabilities.

- ***Human Behavior Modeling*** of individuals, groups, and nations is intended to enhance strategic and tactical decision making, improve immersive training and mission rehearsal, and facilitate cross-cultural coalition building.

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[7] Device Letters, IEEE, Volume: 32 Issue: 12. "N-Polar GaN/AlN MIS-HEMT With of 204 GHz for Ka-Band Applications",

[8] Report of the Defense Science Board Task Force on Basic Research, January 2012,

- ***Nanoscience***, the study and manipulation of the radically different material properties that emerge at the nano-scale, makes possible new classes of electronics and sensors, chemical catalysts, high strength materials, and energetic materials.

Cyber

The Department has a comprehensive strategy for cyber operations, as conveyed in the recently published *DoD Strategy for Operating in Cyberspace*[9]. The strategy sets a framework for cyber research across a wide range of technical areas that result in system and network resiliency, enables agile operations, and assures effective missions. Examples of research programs to support the strategy includes basic research in the science of cyber security; development of trust services that can assess, compose and deploy cyber elements with known and predictable confidence in their identity, functionality and content; research that provides techniques and capabilities to better integrate cyber operations with traditional kinetic capabilities; and research into cyber range infrastructures that can aid in analyzing the impact of new cyber technology within the context of joint force mission scenarios.

New cyber analytic tools are key to technology development and accelerated transition of successful technology development into acquisition programs. To this end, we've started a Cyber Measurement Campaign to measure progress of new cyber capabilities toward program goals. The campaign will include the development of new experimental architectures to enable evaluation of alternative cyber solution approaches. The framework will be used in our cyber ranges, such as the Joint Information Operations Range, to enable a more data-driven evaluation of S&T investments.

Irregular Warfare (IW)

S&T investments in IW address a broad range of operational challenges in battlespace awareness, communications support, building partnership capacity, mission rehearsal and exercise, pursuit and denial, and knowledge management. While all important areas, our experiences in irregular warfare over the past ten years have taught us the tremendous value of battlespace awareness tools. Warfighters have said they need an integrated set of capabilities to sense, localize, and track perceptions, attitudes, beliefs and behaviors of adversaries engaged in irregular warfare. The capabilities would inform analysts about rapidly emerging situations, such as triggers that indicate an impending irregular warfare action, along with tools to provide relevant courses of action. S&T investments to develop battlespace awareness capabilities are primarily aimed at creating new concepts in the social, computational, and information sciences.

Developing an overall integrated set of capabilities for irregular warfare battlespace awareness require new methods for exploitation of multiple heterogeneous sources of information and new methods to overcome noise, clutter, weak signals, and active denial. More capable tag, track and locate capabilities will also aid in successfully differentiating important signals from background clutter. Additionally, improvements to biometrics and forensics capabilities are also needed. The Department's S&T enterprise has investments in all of the above areas.

As new and novel sensors are developed and deployed as irregular warfare capabilities we can expect a significant increase in the amount of structured and unstructured data collected. This

[9] Department of Defense Strategy for Operating in Cyberspace, July 2011,

trend is already evident but the current capabilities to organize and analyze the data are not keeping pace. Commanders at both the strategic and operational levels need new capabilities that rapidly access and organize key information necessary to inform decision making. The data-to-decisions priority area will ensure the Department's investments in this area meet the need.

The Minerva basic research program seeks to develop expertise in the science of human systems and key to future irregular warfare capabilities. The researchers funded by the Minerva program produce insights that lead to a deeper understanding of important social issues affecting global populations. The payoffs from the funded research are improved strategic and operational concepts to thwart terrorism; new concepts to succeed in irregular warfare operations; and new concepts that facilitate the building of new coalitions and strengthening existing coalitions needed to implement the new strategic guidance. As examples, Minerva efforts studied the relationship between violence and the provision of developmental aid in Afghanistan. Minerva program funds will be used to sponsor basic research at universities and faculty chairs at defense education institutions.

Integrated Laboratory Enterprise

The Department operates 67 laboratories across 22 states with a total workforce of 60,000 employees. Over 35,000 of these are degreed scientists and engineers, who conduct DoD-relevant research leading to key technology demonstrations and publish thousands of reports and peer-reviewed technical papers. In many cases, this community defines a technical field with seminal work and leads the industrial base in their respective areas.

The Department also operates 10 Federally Funded Research and Development Centers (FFRDCs), 13 University Affiliated Research Centers (UARCs) and 10 Information Analysis Centers (IACs) across critical disciplines for the Department. These institutions enable the Department to connect with top technical talent across the Nation in fields ranging from cyber security to ballistic missile defense to advanced microelectronics and more. They provide objective systems engineering, objective red team assessments, gold standard test and evaluation, deep dive technical talent and innovative paths for rapid prototyping.

This enterprise is a unique environment for advanced technology development and concept incubation. The Department's laboratories are uniquely suited to couple basic research concepts to early-use military applications. For example, based on work started by the Air Force Research Laboratory, the Air Force Adaptive Versatile Engine Technologies program, "ADVENT," is developing a new jet engine with far greater fuel efficiency, and a much broader range of optimal operating conditions. It is a good example of where a Department laboratory has led the development of new capabilities well beyond the bounds of commercial technology. The ADVENT engine combines the very best performance characteristics of large aircraft engines, like those in tankers and transports, with those of fighters through the use of complex electronic control of air bypass systems and advanced materials to permit higher operating temperatures. Based on successful component tests at the Air Force Research Laboratory, the project is now ready to mature into the Adaptive Engine Technology Development (AETD) project, and the funding request for FY13 will support completion of engine testing to demonstrate the critical technologies leading to preliminary design for full-scale development, including risk reduction of new engine components, integration technologies, engine core maturation, full-scale ground

testing, and analysis of performance. With this phase, the Air Force should be ready for Engineering Manufacturing Development (EMD) within three years.

There are many success stories from each of the labs that the witnesses here today can offer. However, it is important to ensure the Department's laboratories are positioned for success and I will work with each of the Services to determine the resources and processes necessary for their continued success as concept incubators.

Enterprise Initiatives

Across the Department, we continue to improve the S&T enterprise' business process to focus efforts, identify new and emerging research opportunities as well as gaps, and outline investment strategies to accelerate the transition of advanced concepts from research into fielded capabilities.

Over the past year, the Department's S&T Executive Committee comprised of leaders of our S&T organization and leaders from the Joint Staff; OSD Policy, and OSD Manufacturing and Industrial Base have provided key leadership to ensure progress is made within each of the Department's S&T priorities discussed earlier in this testimony. We've established priority steering councils, comprised of S&T experts from across the enterprise, for each of the priority areas. The steering councils develop investment roadmaps, measure progress, and most importantly, coordinate the research investments to ensure maximum efficiency and effectiveness. For Service-specific areas, such as materials or propulsion, we have established communities of interest to coordinate research for maximum effectiveness and efficiency among Department organizations. The priority steering councils and the communities of interest work across the Department and across the Federal research enterprise to calibrate ideas and drive transition of research concepts to industry. These new business processes have empowered the Department's researchers to better communicate the Department's S&T investment strategy to academia and industry leading to much higher quality research proposals.

Technology Transition

We remain committed to technology transition to ensure new technologies have an impact on system procurements when they've reached a sufficient level of maturity. The Department continues to see progress in its technology transition efforts, and the witnesses here today can discuss their individual technology transition processes.

The Department continues to enjoy a strong relationship with industry and academia through a variety of programs designed to foster collaboration, including the Small Business Innovation Research (SBIR) program and Cooperative Research and Development Agreements (CRADA). In fact, in FY 2011, the Department issued approximately 2,000 SBIR Phase 1 awards (as a result of 12,000 proposals), and approximately 900 Phase 2 awards and engaged in approximately 2,500 CRADAs across a broad industrial base. Each of these is an avenue of innovation and a transition path to bring ideas into the Department and transition concepts developed in DoD Laboratories to commercial use.

The Department's Multidisciplinary University Research Initiative (MURI) program has provided additional avenue of technology transition and supports multi-university projects that

bring together prominent scientists focused on pushing the frontiers in emerging areas of science. The MURI program has a demonstrated track record of major accomplishments and has proven to be an excellent source as the seed corn for future capabilities. Over the past year we have invited defense industrial base associations and their member firms to participate in the Department's annual MURI reviews with the goal of cementing partnerships early between the universities' researchers that create the new concepts with the industry developers who have the capacity to mature these concepts into future capabilities for the Department. We are currently engaged in a study to discover new business processes that will accelerate technology developed in our service labs to industry.

Increasing leverage of Industry Independent Research and Development Projects

We have also established new processes to increase the transition of defense industrial base independent research and development (IR&D) investments. Industry's IR&D projects are important source of innovation because they represent an independent and different perspective on the technology solutions needed to solve Department requirements. Importantly, IR&D provides the Department with technology options not available from our labs or contracted research.

Communication is key to maximizing the payoff from IR&D. Industry wants the Department to communicate its capability needs and its plans for future acquisition programs. Government researchers want to know about industry IR&D projects to plan research investments and to plan technology strategies for future acquisition programs. We have taken steps to strengthen this important communication link.

Beginning this year, industry will make available data on their IR&D projects to Government scientists, researchers and acquisition personnel through a new website, the Defense Innovation Marketplace, (www.defenseinnovationmarketplace.mil). The website will also contain current information on Department research priorities and program solicitations - information valuable to industry technology officers as they plan their future IR&D investments. We believe the Marketplace will become a prominent medium connecting industry and government personnel in new and innovative ways leading to more efficient and effective research investments and result in increased transition of innovative technology into future acquisition programs.

Small Business Outreach - Rapid Innovation Program

The Department established a program to implement the FY 2011 National Defense Authorization Act, Section 1073 - the Defense Rapid Innovation Program (RIP). The Department's goals for the RIP is the discovery and transition of innovative technology, primarily from small business, that solve the types of challenges characterized by joint urgent operational needs (JUONs), other critical national security needs, and technology to improve acquisition program success.

Beginning in September 2011, the Services and the Office of Small Business Programs (OSBP) issued broad agency announcements to solicit proposals for RIP funds[10]. The four solicitations

[10] Office of Small Business Programs Solicitation Number HQ0034-11-BAA-RIF-0001
Army Solicitation Number W911NF11R0017

addressed a broad range of needs and we received over 3,500 responses, and the majority of the responses were from small businesses. Contract awards are imminent and will continue through the remainder of FY12. The Department is examining options to effectively use the FY 2012 RIP appropriation of $200 million.

Rapid Fielding - Lessons to be retained

Over the past decade, the Department has greatly expanded its ability to rapidly field warfighter capabilities, based on urgent needs, using streamlined response processes. While these efforts have been correctly focused on theater contingency operations, we now seek to institutionalize rapid fielding as a core competency to affect the cost savings and the acquisition effectiveness that are hallmarks of these efforts. Rapid response is also a new necessity, due to the pace of technology globalization and adversaries' demonstrated ability to innovatively employ that technology. The OSD Rapid Fielding Office (RFO) partners with COCOMs and Military Departments to develop innovative concepts and capability prototypes that accelerate the delivery of technical capabilities to support the current war; mitigate cost schedule or technical risk for major acquisition programs; and prepare for an uncertain future and respond to the fast pace of technological change.

The RFO uses the Joint Capability Technology Demonstration (JCTD) program and the Defense Acquisition Challenge (DAC) to develop effective solutions to time-sensitive operational needs, most well inside 24 months. The CLOUDBREAK program is one example of a rapid response JCTD to develop a novel command and control capability for United States Pacific Command. Similarly, the RFO is supporting United States Central Command (CENTCOM) in developing new force protection and battlespace awareness capabilities to counter insurgents. Project examples include hostile fire protection for rotary wing vehicles, and a family of next generation surveillance systems.

Traditional lengthy engineering and risk reduction processes add to cost, and sometimes render systems out-of-date before they are fielded. Our experience with rapid fielding has shown that we can often successfully reduce these timelines using partnership processes without greatly adding to program risk. For example, the "Fire Resistant Ghillie Suit and Accessory Kit" was developed as part of the Defense Acquisition Challenge Program. Started in FY10 and fielded within one year, the project delivered a fire resistant suit with a comprehensive camouflage system, especially designed for military sharp-shooters. The Deer Park JCTD project (also called ADDER) provided an enhanced and crucial ISR capability to the field, deployed in the Lockheed Martin Senior Scout facility aboard a C130 aircraft. It was conceived and delivered in less than a year, and deployed to CENTCOM in January, 2011. The Rapid Reaction Tunnel Detection JCTD, in roughly one year, provided a novel set of tunnel detection capabilities for United States Northern Command and CENTCOM. The technology was provided to CENTCOM as a response to a Joint Urgent Operational Need, and has since been employed along the U.S. southwest border for drug smuggling interdiction.

Going forward, the RFO is investigating investments that would quickly initiate a response to potential force application threats, or tackle a recently identified vulnerability in an adversary's defensive command and control architecture. Rapid fielding has proven to be a valued

contributor in addressing joint, coalition time-sensitive operational needs. It has shown to be able to deliver technologies that can easily adapt to assist in supporting civil agencies here at home or in devising novel concepts to mitigate the risk to an acquisition program, and shorten the delivery time to the end users.

Trusted Systems

The globalization of technology and supply chains increases risk to our systems of maliciously inserted counterfeit parts and other vulnerabilities. The Department has developed processes and capabilities that increase the trust that our systems will perform only as designed and as the operators intend. There is a new acquisition security policy that provides for a coherent strategy for trusted systems to addresses supply chain risks and system design vulnerabilities.

The Department's dependence upon trusted, leading edge microelectronics is a key part of our trust strategy. Microelectronic components typically drive mission critical performance, and are potential targets for fraud and malice. Over the past year the Department has made significant progress in developing a trusted foundry system underpinned by the Defense Microelectronics Activity as a supplier of last resort.

Defense Microelectronics Activity Next Generation Foundry

Most domestic semiconductor foundries will not continue to produce low-volume, high-mix microelectronics since it provides little profit. In fact, industry is rapidly moving away from production of 90nanometer (nm) chips, instead focusing on 45nm and 28 nm chips. For example, Intel Corporation no longer manufactures their 90 nm Pentium microprocessors. Since 90 nm technology is a key size for robust and rugged defense applications the Department must put in place resources to ensure this technology is available in the future. The FY 2013 PBR requests funds for the DMEA to extend its current capability to 90nm. Appropriating the funds now provides sufficient time to buy used equipment at extremely low cost from commercial sources and implement production processes. DMEA will be a provider of last resort operating without commercial conflicts and provide commercial sources the first right of refusal to produce components to meet DoD needs. Without extending the existing foundry at DMEA to 90nm, the DoD could soon be without a trusted and assured source for the repeatable procurement of state-of-the-practice integrated circuits that comprise a vast majority of the U.S. arsenal's microelectronics.

Electronic Warfare Joint Capability Office

For decades the U.S. has enjoyed the strategic advantage of long-range precision sensors and weapons combined with uncontested Electronic Warfare superiority and stealth platforms. Against less technologically advanced adversaries this combination has proven itself unbeatable, yielding a massive overmatch to U.S. lethality and battle space maneuver.

The world in which this advantage was established is changing rapidly. The global pace of technology proliferation coupled with increasingly rapid changes in foreign sensor sophistication, adversary weapon lethality, and expanding weapon engagement ranges are changing the dynamics of warfare.

To meet this challenge, the Department is establishing the Electronic Warfare Joint Capability Office focused on determining the S&T investments that lead to superior means of disrupting

adversary sensors, weapons and control functions by exploring new concepts in electronic attack. This new office will combine the best and brightest among the Service labs, FFRDCs, universities and industry centers across the country to ensure the Joint Forces maintain their technology advantage in electronic warfare.

Science Technology Engineering and Math Initiative

We also ask your support to continue our efforts to ensure a pipeline of personnel with appropriate science, technology, engineering, and mathematics (STEM) qualifications for DoD and the industrial base. We remain concerned with the future availability of high-caliber scientists and engineers. For DoD, we confront an especially challenging environment—a reduced production of graduates in scientific fields that are important to support defense needs, while the existing supply of knowledgeable scientists and engineers declines due to retirements and competing opportunities. Our office is executing a strategy aimed to meet these challenges—The DoD STEM Education and Outreach Strategic Plan.

The strategy is implemented within DoD through a set of programs. One important program is the National Defense Education Program, which includes projects for pre-college, for university students, and for faculty fellowships, specifically fostering interest in defense science. Since its inception, the Science, Mathematics, and Research for Transformation (SMART) program for undergraduate and graduate students, for example, has transitioned more than 430 young scientists and engineers into the DoD, and has involved over 270 institutions of higher learning and research organizations. The National Security Science and Engineering Faculty Fellowship program supports some of the nation's top scientists at prestigious universities around the country, enabling them to focus their research groups on technical areas of critical important to DoD and national security. And the NDEP K-12 program engages DoD scientists and engineers in classrooms around the country to serve as role models, mentors, lecturers, and competition judges. To date, more than 1750 DoD scientists and engineers have been engaged in K-12 activities.

Conclusion

The Joint Forces ability to project power and succeed in operations will be increasingly challenged by new capabilities and tactics. The clear technical advantage our forces enjoyed is not guaranteed – the rise in global research and development investments and the globalization of technology has collapsed the pace of innovation for both the U.S. and our adversaries. Now more than ever the U.S. must maintain its traditional leadership position in research and development. The President's FY 2013 budget request provides the right mix of programs and investments in basic, applied, and advanced research to maintain our leadership position. The S&T enterprise initiatives we are enacting ensure the resources are invested wisely, and with focus, and accelerates the transition of concepts into capabilities. I appreciate Congress' continued support of our S&T efforts and I look forward to answering your questions.

Zachary J. Lemnios

Assistant Secretary of Defense for Research & Engineering for Department of Defense

The Honorable Zachary J. Lemnios was confirmed by the United States Senate on June 19, 2009 and sworn in on July 2, 2009. The Assistant Secretary of Defense for Research and Engineering (ASD(R&E)) is the Department of Defense's (DoD's) Chief Technology Office, providing thought leadership for the Department's near-, mid- and far-term research and engineering efforts to develop the technical capabilities to support the Secretary of Defense goals and priorities and the principal staff advisor for research and engineering matters to the Under Secretary of Defense for Acquisition, Technology, and Logistics (USD(AT&L)).

ASD(R&E) implements its mission by operating in a culture of innovation, speed, and agility to rapidly develop breakthrough technologies, prepare for an uncertain future and strengthen the foundation of DoD's acquisition programs through scientific and engineering support. As DoD's Chief Technology Office, ASD(R&E) operates in collaboration and cooperation with industry, academia, and government S&T organizations -- the "Research Triple" – to discover, develop, and deploy new science and new technology concepts to support national security.

Mr. Lemnios is a Principal member, Committee on Technology of the National Science and Technology Council; Advisor, Defense Acquisition Board; Chairman, Radiation Hardened Oversight Council (RHOC); Chairman, Defense Science and Technology Advisory Group (DSTAG); Chairman, Armed Services Biomedical Research Evaluation and Management Committee; Chairman, DoD Combat Feeding Research and Engineering Board (CFREB); and Chairman, DoD Biometrics Executive Committee.

Before assuming this position, Mr. Lemnios was the Chief Technology Officer of MIT Lincoln Laboratory, responsible for coordinating technology strategy across the organization and for establishing and growing external strategic relationships to support current and future Laboratory missions. He also served as Assistant Division Head of the MIT Lincoln Laboratory Solid State Division, as a member of the Laboratory's Senior Management Council and as the Co-Chair of the Laboratory's New Technology Initiative (NTI) Board.

Between 2002 and 2005, while at the Defense Advanced Research Projects Agency (DARPA), Mr. Lemnios was Director of the Microsystems Technology Office (MTO), and previous to that, the Deputy Director of the Information Processing Technology Office (IPTO). In these positions, he oversaw the development of future research thrusts, analyzed and evaluated program proposals and engagements with commercial, academic organizations and represented DARPA on various national committees.

Mr. Lemnios held various positions within industry at Hughes Aircraft Company, Westinghouse Electric Corporation and Ford Microelectronics, Inc. that led to the development and demonstration of advanced microelectronic components. He has served on numerous DoD, industry and academic committees.

Mr. Lemnios received his BSEE from the University of Michigan and his MSEE from Washington University in St. Louis. He has authored over 40 papers, holds 4 patents in advanced GaAs device and MMIC technology and is a Senior Member of the IEEE.

STATEMENT BY
DR. MARILYN FREEMAN

DEPUTY ASSISTANT SECRETARY OF THE ARMY

FOR RESEARCH AND TECHNOLOGY

ON

THE UNITED STATES ARMY'S SCIENCE AND TECHNOLOGY (S&T)

PROGRAM FOR FISCAL YEAR 2013

SECOND SESSION, 112TH CONGRESS

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STATEMENT BY
DR. MARILYN FREEMAN

DEPUTY ASSISTANT SECRETARY OF THE ARMY

FOR RESEARCH AND TECHNOLOGY

Mr. Chairman and Members of the Subcommittee, thank you for the opportunity to discuss the Army's Science and Technology (S&T) Program for fiscal year (FY) 2013.

As you know, the Army's S&T community has had, and will continue to have, a significant role in supporting the Warfighter. We have consistently delivered technology solutions needed for recent conflicts and we are committed to developing technologies that will enhance the Army's capabilities, which will be needed to prevent, shape and win future conflicts in an uncertain, complex world. We are grateful to the members of this Committee for your sustained support of our Soldiers, your support of our laboratories and centers (and the technically excellent work force that comprises them), and your continued commitment to ensure that funding is always available to provide our current and future Soldiers with the technology that enables them to defend America's interests and those of our allies around the world.

The overarching vision for Army S&T is to invent, innovate and demonstrate technology enabled capabilities that empower, unburden and protect our Soldiers. Based on the past decade of war we know that technology makes possible dramatic success both in direct combat and in all other missions that our Soldiers must conduct in the various theaters of operation.

I hear often from the Soldiers themselves that technology saved their lives and was critical to their remarkable accomplishments. This feedback motivates our Scientists and Engineers, who use the funding provided by the Congress, to research, mature and develop advanced technologies – from armor to combat casualty care, from ground vehicles to air vehicles, from uniforms to food, from small arms to missiles, and from communications to training. They apply their knowledge, experimental data, and products to solve problems, enhance performance, provide new desired capabilities, and forecast what capabilities are within the realm of the possible for our Army. Army S&T is committed to providing technologies to keep our decisive edge against adaptive enemies.

Management of the S&T Portfolio

One of my first priorities, when I became DASA(RT) a year and a half ago, was to change the perception that Army S&T was irrelevant – and this remains one of my top goals. I embarked on a path to: 1) provide a discipline and structure to the way we plan and execute our S&T programs; 2) develop effective partnerships with key stakeholders, leaders and Users across traditional organizational stovepipes; and 3) better synchronize our programs with the priorities of the Secretary of the Army, the Army Force Generation (ARFORGEN) plan, and the fiscal processes of the Department of Defense. This path is leading to a significant change of the S&T culture and it is still a work in progress.

Over the past year we have developed several management initiatives to emplace a structure and set of tools, which will enable us to be successful on our journey to relevance, and to develop a balanced portfolio based on prioritized needs and desired advanced capabilities. The first initiative was to restructure the way we think of and articulate the S&T program. We established a set of S&T Portfolios. The portfolio construct allows us to focus more on the desired capabilities for the domains in which the Army operates than on the color of money in various commodity stovepipes. The main S&T portfolios are: Soldier; Ground; Air; and Command, Control, Communications and Intelligence (C3I). We also have a Basic Research portfolio. These align closely to the Army's capability portfolios. Our intent is to be able to show how our S&T programs and products support the Army's Capability Portfolio Review process. We are also integrating our efforts with the Department of Defense's seven S&T priorities.

The second initiative was to increase active engagement of the Army Leadership (Headquarters Department of the Army, the Training and Doctrine Command (TRADOC), the Acquisition community and the major commands) in activities that establish real priorities for Army S&T.

The third initiative was to focus on better, more comprehensive program planning. By doing more concepting, detailed schedule planning, and realistic program cost estimates before embarking on a path of research and development, we can better articulate the objectives of our programs, show the value of them, and track transitions to help us measure success.

Today I am proud to report to you that there has been a great deal of forward progress. We have built a much stronger partnership with Army Leadership, the

Acquisition Executives and TRADOC. In the past year we established a strategic program planning process with participation of both our key partners and S&T leaders across all the laboratories and centers. Collaboratively we developed and validated the first (ever) set of S&T priorities to focus our near term research and development efforts. We started by generating a list of seven (7) problems that Soldiers and Small Combat Units are grappling with today and for which they will continue to need better solutions over the next several years. Then we collaboratively developed a set of challenges associated with those problems – twenty four (24) in all - to be used by the S&T community to plan programs that will address them or solve them by the end of FY 2017.

The problems and associated challenges constitute a fundamentally new approach to planning and managing our S&T investment. In this first year we concentrated on the top ten (10) challenges, selected by Senior Army Leadership. The laboratories and centers teamed up to develop the first Technology Enabled Capability Demonstration (TECD) programs. Typically a TECD will mature and bring together several new technologies, couple them with existing systems/technologies, and demonstrate integrated technology-based solutions that either measurably enhance performance and effectiveness of an existing capability or enable a new and necessary capability. Nine (9) TECD programs were formulated and approved in this first round. Most of the 9 new TECD programs will begin in FY2013 and funding for them is reflected in our FY2013 Budget Request. The community has already begun collaboratively planning the set of fifteen (15) remaining programs that will be brought forward to Army leadership for validation within this fiscal year. We will be addressing any shifts in the budget required to accomplish this second set of TECDs in the FY2014 budget cycle.

My goal is to have approximately fifty (50) percent of the Army's Budget Activity (BA) 3 funding dedicated to TECDs. We will be scrutinizing these programs constantly; requiring their Technology Program Managers (TPMs) to focus on cost, schedule and transition of deliverables; and we will be generating new problems/challenges as necessary to respond to the changing needs of our Soldiers.

TECDs are focused on near term Army priorities. They are a good first step. But, in order to maintain a balanced portfolio, we must also have clearer priorities for the mid and far term investments. Therefore, this year we are also working to define and develop a set of programs to meet the mid-term needs of the Acquisition community. Having these needs identified and then prioritized by leadership will enable us to better focus the remainder of our BA 3 dollars and a portion of our BA 2 dollars on near- to mid-term solutions to critical emerging

needs. Simultaneously, we are identifying technologies that have high potential to "Bridge Gaps" or achieve "Leap Ahead" capabilities. If we lead the way in developing a set of critical technologies in our BA 2 and BA 3 programs at the same time when acquisition programs may be slowing down due to budget constraints, we believe that we will be better positioned for the future. We are thinking of calling these programs Science and Technology Enabling Programs (STEPs). Finally, we are going to establish a set of priorities for Basic Research. It is my goal to use the collaborative processes (similar to those used to create the TECDs) to get clear priorities, problems and challenges against which better programs can be formulated and executed to achieve the most advanced capabilities possible, as soon as possible, with the resources you make available to us.

As we shift to a priority based, programmatically managed, more collaborative S&T culture within the Army, our Scientists and Engineers have not stopped working the existing efforts across the entire spectrum of the funding lines and the technology areas. Even as they are taking on the new challenges I have given them, they continue to deliver on projects that research, mature and demonstrate needed technology devices, components and subsystems –many of which will feed future STEPs or TECDs. Many of our major efforts will be described later in this testimony.

The FY 2013 Budget Request

I believe the FY 2013 Budget request submitted to the Congress provides the correct levels of investment for our enterprise. Our S&T program request for BA1-3 for FY2013 is $2.2 billion - a 3.2% decrease from our FY2012 request. BA3 programs decrease by $86 million, while BA1 and BA2 programs increase by $7 million and $6 million, respectively.

In FY2013 the Army is placing increased emphasis (and investment) on ground and aviation vehicle survivability, research in focal plane arrays, and alternative fuels for ground vehicles. We will accept some greater risk (reducing funding) in lethality, unmanned/autonomous ground vehicles, and military engineering. As we adjust to an era of decreasing or flat budgets, Army S&T must be capable of doing more with less and correctly managing the risk associated with shrinking budgets by identifying and focusing on the highest priorities for the future. I believe that the S&T management strategy, described previously, allows us to do just that.

In FY2013 we requested $386.1 million for our Soldier portfolio, $626.9 million for our Ground Portfolio, $141.3 million for our Air Portfolio and $323.0 million for our C3I Portfolio. We also requested $444.1 million for Basic Research.

In the request there is $14.0 million for the BA4 Technology Maturation Initiatives line, which was established in FY 2012 to better enable the Army to meet the goal of ensuring competition while maturing S&T efforts to Technology Readiness Level (TRL) 6 or higher prior to Milestone B in support of the Weapons System Acquisition Reform Act of 2009. Funding in this line is expected to help us cross the "valley of death" for some high potential technologies or subsystems.

To make the decisions concerning which efforts should be funded with this precious resource, we established an S&T BA4 Executive Steering Group (ESG) and a rigorous, but streamlined, process for evaluating, prioritizing and selecting proposed projects. The project selection criteria include: potential to reduce programmatic costs/risks, potential for quick transitions, and synchronization with acquisition plans and programs. Last fall, the ESG selected the first five (5) projects for funding in FY2012. These projects will be continually monitored to ensure that they stay on track to provide the deliverables to the proper PMs/PEOs within the next couple of years. Of course, it is too early to make any conclusions regarding the success of this new approach, but the ultimate test of success will be whether or not we achieve planned transitions and reduce costs through early competitive prototyping. I am confident that we have a strong process in place now, which provides the Army with an improved mechanism for establishing a closer alignment between S&T and acquisition programs; however, in the FY2013 Budget Request, we did decide to maintain a modest investment in this line until we have some data on the effectiveness of the projects against the objectives.

Another new source of funding for S&T is the Rapid Innovation Fund (RIF), established by Congress in FY2011. We are using, and intend to continue using, this additional funding to attract small and non-traditional businesses, so that we can identify and incorporate what they produce to help our TECD TPMs solve the twenty-four (24) challenges. We recently released a Broad Agency Announcement (BAA) asking for white papers in support of the top ten (10) Army priority challenges. The response was enormous - nearly 1,000 white papers were received. My staff, along with subject matter experts from the Army labs and the acquisition community, reviewed each of these proposals and selected over ninety (90). We are asking these selectees to submit full proposals; against which we will use the FY2011 and FY 2012 RIF funding to award contracts. These contractual efforts will be managed as part of the appropriate TECD by the

TPMs. The plan is to issue another BAA in FY2012 seeking technologies that can contribute to solving the remaining fifteen (15) priority challenges. I believe that this new initiative (the RIF) is providing value to the Army and opening up more collaborative opportunities for small and non-traditional businesses. In addition to providing a link to the TECDs for small businesses, the huge number of white papers received has given us further insight into innovative technologies of which we may have not been otherwise aware – and it is our intent to fund more of the highest quality proposals with core funds. While we are still in the initial phase of this program, I have confidence it will be ultimately successful in reaching companies with innovative ideas and getting them on a path for Army's acceptance of their products into subsystems and systems.

The Army Small Business Innovation Research (SBIR) program is another way for us to tap the ideas of non-traditional defense businesses. The SBIR program is designed to provide small, high-tech businesses the opportunity to propose innovative research and development solutions in response to critical Army needs. In Fiscal Year 2011, the Army SBIR office generated one hundred thirty-nine (139) topics based on input from laboratories, TRADOC and the PEOs. In response to these topics, small businesses submitted over 3000 proposals, which were evaluated by the Army SBIR office and which resulted in more than six hundred (600) Phase I and Phase II awards valued at approximately $200M.

Although the SIBR program is strong, there is a real need to streamline the topics generation process and reduce the overhead and labor associated with generating, selecting and contracting SIBR efforts. I believe we can lean the process, increase the program success rates and, most importantly, improve the transition of products that are developed under Army SIBR contracts. Therefore, I have directed that, beginning this year, SBIR topics/projects align with TECDs, S&T Challenges and highest priority Program Executive Office (PEO) needs. By tying more of these efforts directly to S&T priorities and managing each project as part of a TECD program, the FY 2013 SIBR projects may have greater transition rate and increased relevance.

Beginning in FY2012 the High Performance Computing Modernization Program (HPCMP) and office transitioned from the Office of the Secretary of Defense (OSD) to my office for management. HPCMP is, and will remain, focused on supporting the needs of the tri-services and other agencies. HPCMP comprises three (3) elements - it: 1) operates six (6) DOD Shared Resource Centers; 2) operates and maintains the Defense Research and Engineering Network; and 3) develops Software Applications. DOD scientists and engineers use HPCMP resources in support of many disciplines, including physics, chemistry, materials, acoustics, and aerodynamics. While there have been some bumps in the road in

the transition process, the Army remains fully committed to managing and executing this critical capability. In FY2013 we have requested $180.6 million in RDT&E and $57.7 million in procurement to conduct this program, managed by the U.S. Army Corps of Engineers.

Across all of our portfolios, we maintain our focus on power and energy. As we develop technology enabled capabilities, we must work to reduce the burden in both weight and logistics that comes from increased energy consumption by the plethora of electronic equipment we need in our operations. Since FY2002, S&T power and energy research has concentrated on maturation and demonstration of components, materials, and devices to reduce size, weight and power, as well as, extend the useful life of components. We are now shifting our focus to concentrate on subsystems and systems. Our objectives are to improve efficiency and reduce consumption while increasing functionality and developing smart energy-saving designs. Power and energy issues must be resolved to achieve the objectives of most of the twenty-four (24) challenges. Our existing programs are integrated with, and complementary to, the operational energy strategy of the Assistant Secretary of the Army for Installations, Energy and the Environment. In the FY2013 Budget Request we have, interspersed among our portfolios, $160.9 million for power and energy projects.

S&T Portfolio highlights

Soldier Portfolio

In keeping with the vision of Soldier as the Decisive Weapon, the Soldier S&T portfolio researches underpinning human science and matures and demonstrates technologies for Soldier and Squad Lethality, Survivability, Mobility, Leader Development, Training, Combat Casualty Care and Clinical and Rehabilitation Medicine capabilities. The efforts in this portfolio are designed to maximize the effectiveness of Squad performance as a collective formation. These efforts result in state of the art equipment, shelters, clothing, food, training tools, logistic support, combat trauma therapies, and other medical technologies. Major initiatives include Protection, Dismounted Soldier Power and an overarching focus on the human and material science advancements necessary to Lighten the Soldier's Load. In the coming years, improving mission performance in a complex and dynamic environment will rely on improving the integration of cognitive and physical performance with technology solutions.

In keeping with our holistic approach to Army challenges, this effort looks to address the entire chain of service from pre-deployment to return to civilian life including training, health promotion, rehabilitative medicine and treatment for

Post-Traumatic Stress Disorder (PTSD)/Traumatic Brain Injury (TBI). Efforts seek to reduce load-related injuries and chronic conditions, address the cognitive and physical burden through better decision and mission planning tools, and optimize individual protective equipment to fully consider survivability in relation to mobility, lethality, and the human dimension. This effort is truly collaborative, involving researchers from the Natick Soldier Research, Development and Engineering Center, the Army Research Lab, the Medical Research and Materiel Command, the Army Research Institute, the Armaments Research, Development and Engineering Center, the other Services and DARPA, as well as our academic, industry, and international partners.

PTSD and TBI continue to be a source of serious concern. The U.S. Army Medical Research and Materiel Command (MRMC) has ongoing efforts to address these devastating conditions. Basic research efforts include: furthering our understanding of cell death signals and neuroprotection mechanisms, as well as, identifying critical thresholds for secondary injury comprising TBI. We are also focused on investigating selective brain cooling and non-embryonic stem cells derived from human amniotic fluid as non-traditional therapies for TBI, and identifying "combination" therapeutics that substantially mitigate or reduce TBI-induced brain damage and seizures for advanced development and clinical trials. We have had some recent successes in this area, including completion of an FDA effectiveness study on a candidate neuroprotective drug for treatment of TBI and completion of a pivotal trial for a bench-top assay for use in hospitals using candidate biomarkers for the detection of TBI.

Ground Portfolio

The Ground portfolio includes technologies for medium and large caliber weapons, munitions, missiles, directed energy weapons, vehicle ballistic and blast protection, vehicle power and mobility, unmanned ground systems and countermine & counter Improvised Explosive Devices (IED) detection and neutralization and deployable small base protection.

In the past, we have designed vehicles with little consideration for accommodating Soldiers who have to operate in them. Now we are beginning to explore ways to design vehicles around Soldiers. Increasing protection levels of the platforms means impacting interior volumes reducing mobility, maneuverability, and freedom of movement for occupants, and leads to heavier platforms. The Occupant Centric Survivability (OCS) Program provides the mechanism to develop, design, demonstrate, and document an occupant centered Army ground vehicle design philosophy that improves vehicle survivability, as well as force protection, by mitigating Warfighter injury due to

underbody IED & mine blast, vehicle rollover, and vehicle crash events. This design philosophy considers the Warfighter first, integrates occupant protection technologies, and builds the vehicle to surround and support the Warfighter and the Warfighter's mission. To this end, we are developing an OCS concept design demonstrator, as well as, platform-specific demonstrators with unique occupant protection technologies tailored to the platform design constraints. We are also publishing standards for occupant centric design guidelines, test procedures and safety specifications.

In FY2013, we are also continuing the effort started last year in Underbody Blast (UBB) Protection. Some recent successes include performing vulnerability identification and resolution on most Program Manager (PM) programs such as JLTV, MRAP, Stryker, HET, and FMTV, and advising PM customers on the feasibility and performance of potential blast protection technologies while balancing cost, payload, mobility and mission requirements. We have developed tools and methods which have lead to system level evaluations through modeling & simulation resulting in improved Live Fire Test and Evaluation, faster delivery of technologies to theater/customers and necessary characterizations of threats, systems and environment. Our efforts continue to look at a full range of technologies to address this issue, from modeling and simulation and physiological studies to seats, restraints and energy-absorbing materials.

We are also continuing our investments and efforts in Deployable Force Protection (DFP). Our military units operating remotely at small bases are more vulnerable to enemy attacks because they have less organic equipment, fewer personnel, shorter kinetic reach, less hardened areas, significant bandwidth limitations and are difficult to reinforce, resupply and support with repairs. We are developing force protection technologies that have a low logistics footprint, are easily operated with limited manpower and training, and are quick to set up and take down. This will allow for enhanced protection capabilities, while leaving Soldiers with more time to perform their mission.

In conjunction with the U.S. Special Operations Command Central (USSOCCENT) and the Combating Terrorism Technical Support Office, we recently assessed several systems and recommended an integrated force protection kit to support Village Stability Operations. The kit is being provided to the 7th Special Forces Group for operational assessment in theater and was created in a collaborative effort to accelerate delivery. The kit provides protection and allows operators to focus less on establishing personal security and more on the mission. We have also developed a low-logistics armoring system to expediently establish protection for critical assets, such as the Tactical Operations Center (TOC), mortar pit, and weapon/sensor systems. Unlike any

other, this system also provides expedient overhead cover that protects against direct-hit rocket, artillery, and mortar threats. Members of the DFP team worked with troops and Centers of Excellence on design and employment options. The 2nd Battalion, 1st Brigade, 82nd Airborne Division will deploy with a number of modular protective mortar pit and overhead cover systems to be used in an operational assessment in theater. Use of these systems will result in savings of countless hours that are typically associated with establishing mortar pits and protection and will increase the associated level of protection for Soldiers.

Air Portfolio

The Army is the lead service for rotorcraft, owning and operating over 80% of the Department of Defense's vertical lift aircraft. As such, the preponderance of rotorcraft technology research and development takes place within the Army. The Air portfolio is focused on seven broad areas of research: platform technology; operations and support; survivability; rotors and flight controls; engines & drives; weapons and sensors; and unmanned systems. Our vision for Army aviation S&T is to provide the best possible aviation technology enabled capabilities to deliver Soldiers, weapons, supplies and equipment where they are needed, when they are needed.

In order to provide Soldier support over future Areas of Operation (AO) that may be sixteen times larger than current AOs, the Army needs a faster, more efficient rotorcraft, with significantly improved survivability against current and future threats. Operating in conditions of 6000 feet and 95 degrees (high/hot), this aircraft will need to transport and supply troops while providing close air support and intelligence, surveillance and reconnaissance capabilities.

A major effort currently underway within S&T is technology development for the Department of Defense's next potential "clean sheet" design rotorcraft - the Joint Multi-Role (JMR) aircraft. In FY2011, the Army, Navy and NASA agreed to use a common toolset and database and are collaboratively sharing design responsibility for the JMR-Medium, an aircraft intended to replace our Blackhawk/Seahawk and Apache fleet. Three different configurations of JMR aircraft have been designed by the Government - a conventional helicopter, a large-wing slowed rotor compound, and a tilt rotor. There are seven design excursions being investigated that fully explore the size and environmental characteristics of interest, including shipboard operations. Additional near-term plans include conducting a small scale wind tunnel test of an unpowered tilt rotor to validate forces and moments, confirm Computational Fluid Dynamics (CFD) estimates, and update design parameters. Additional CFD/Computational Structural Dynamics assessment and results integration will be done as part of

expanding the design methodology and toolset. We plan to use the BA4 line to allow a second demonstrator to be developed for JMR.

Additionally, the DoD HPCMP CREATE Air Vehicle Project is coordinated with this activity and endeavors to increase the fidelity of the design process with the future goal of being able to conduct a complete detailed design environment.

While many of our rotorcraft research efforts are focused on the development of technology for transition to new platforms in 2025 and beyond, we are also maintaining an investment to keep the current fleet effective. One recent transition success has been the Advanced Affordable Turbine Engine (AATE), a 3000 shaft horsepower engine with 25% improved fuel efficiency, and 35% reduced lifecycle costs. In FY2012, AATE transitioned to PM - Utility for Engineering and Manufacturing Development under the Improved Turbine Engine Program, which will re-engine our Blackhawk and Apache fleet.

C3I Portfolio

The key to successful operations in an increasingly complex battle space is the capability for seamless and timely communications across all echelons of the system, from headquarters to the Soldier. A major effort in the C3 portfolio is combining enhanced mission command capabilities for the Soldier and small unit with improved mobile networks.

We are providing solutions to improve command and control, situational awareness, and dynamic communications, while maintaining appropriate military security not found in commercial devices. In order to exploit the full range of capabilities that smart devices offer the Soldier, we need an improved network in an on-the-move (OTM) environment; handheld devices with tools and functionality to provide Soldiers with the necessary decision and communications capabilities in an intuitive interface; and appropriate security protocols for the battlefield.

Our mobile network research efforts are increasing network efficiency and reliability, increasing OTM connectivity and bandwidth utilization, and allowing for reliable message delivery in difficult communications environments. These efforts are leveraging investments by commercial industry and DARPA.

Our mission command efforts are aimed at providing Soldiers and small units with the kinds of data-driven decision tools once available only to higher echelons. As our defense strategy moves to a smaller, more agile force, it is critical that small units and individual Soldiers have access to accurate and relevant situation awareness information including geospatial and meteorological

data, combat ID and battlespace awareness, as well as full spectrum decision support tools. Just as critically, we have to design these tools taking into account human cognitive abilities and limitations.

Finally, the most useful tools for the Soldier are worthless if they are not properly secured. These security issues include approved encryption for Secret and Below, identity management, security policy management, exploitable applications and securing the infrastructure. Our efforts in this area include authentication of approved applications and prevention of installation of rogue applications, providing Secret voice and data connections across disparate technologies including handheld devices, and developing a mutual authentication mechanism between users, handheld devices, and the network core.

Beyond the specific security efforts for mobile battlefield communications, the C3 portfolio also directs our broader cyber security S&T efforts, which I know the subcommittee has a particular interest in. Our work in a resilient cyber security framework will provide a more secure foundation in which participants, including cyber devices and software, are able to work together in near-real time to anticipate and prevent cyber attacks, limit the spread of attacks across participating devices, minimize the consequences of attacks, and recover systems and networks to trusted states. Within this framework, security capabilities are built into cyber devices and software in a way that allows preventive and defensive courses of action to be coordinated within and among communities of defense in depth architectures. The power to detect and mitigate threats is distributed among participants and near-real time coordination is enabled by combining the innate and interoperable capabilities of individual devices with trusted information exchanges and shared, configurable policies.

In the area of software assurance, analyzing software code for security vulnerabilities and malware is a manually intensive effort requiring a high degree of skill and experience. Our development efforts focus on automating the software code analysis for C++ programs and JAVA source code; developing a compliance checker to ensure that the software has been developed in accordance with required standards; reducing false positives; and testing binary objects and images for logic bombs and unexecuted regions. We also have research efforts in hardware assurance, including trustworthy computing foundations, physical tamper and chip level protection schemes.

Basic Research

Underpinning all of our efforts is a strong basic research program. Beginning this year, we are developing a process similar to the TECDs to define a set of

priorities for Basic Research and identify challenge statements against which programs can be proposed and approved. The key emphasis for the Army is to provide the necessary basic research (through the skills of our workforce and our investments) to achieve and provide for technically enabled capabilities that meet the specific needs of the Soldier and the Army mission. In Army Basic Research, we are looking to lead the S&T enterprise. We look for guidance from many sources – requirements and desired capabilities from TRADOC and our Soldiers; commissioned studies from the National Academies and RAND; workshops and collaborations with our sister services; and we are in the midst of re-thinking how we approach, describe, and provide strategy for the overall program.

We know that for most of the 20th century, physics was the fundamental driver for nearly all leaps in technology. And while physics will always play a large role in that, over the last 20 years we have seen big changes in and big advances from biology and bio-inspired technology. As we move forward we need to watch very closely and invest selectively to determine what technology is going to come from that and how are we going to develop that to assist the Soldier. With that in mind, we are beginning to think of and align our basic research efforts in three areas: Long-Term Exploration; Long-Term Disruptive Technology investments; and Long-Term Enabling Research.

Long-Term Exploration efforts look to discover or invent new technologies and capabilities relevant to the Army mission - we explore with a purpose. Our Long-Term Disruptive Technology investments are researching technologies which will change the rules of the playing field for our Warfighter. Long-Term Enabling research looks for innovative ways to move the inventions and discoveries into components and subcomponents and technologies that our labs and research partners can exploit. By this we enable future S&T applied research, advanced tech development, and capabilities. Taken together, this basic research provides the solid foundation for Army S&T.

Laboratory Management

While I believe we are generally well-positioned to weather the current budget climate, I do have major concerns with the long term health of our laboratory and center system. Without the world-class cadre of scientists and engineers, and the infrastructure that supports their work, the Army S&T enterprise would be in serious trouble. To maintain technological superiority now and in the future, the Army must continue to attract and retain the best science and engineering talent into the Army Laboratories and Centers. Our laboratory personnel demonstrations give us the flexibility to enhance recruiting and afford the opportunity to reshape our workforce, and I appreciate Congress' continued

support for these authorities. All of our Science and Technology Reinvention Laboratories are now operating under this program. These initiatives are unique to each laboratory, allowing the maximum management flexibility for the laboratory directors to shape their workforce and remain competitive with the private sector.

When faced with declining budgets, the easiest place to find savings is often in personnel. The S&T personnel at our labs and centers are generally not members of the Acquisition Workforce, and therefore do not enjoy the same protections from workforce reductions. The loss of this kind of talent is difficult to undo, and frankly it may be impossible to replace these people once they are gone. While I do not have a good solution to this problem, I look forward to working with Congress in the coming months and years to ensure that the health of our labs and centers, which are vital to the future capabilities of our Soldiers, remains strong.

In terms of infrastructure, we have long worked to make improvements at the margins, and where possible we have used the Defense Base Closure and Realignment (BRAC) Commission process to modernize facilities and infrastructure. This is not a long-term solution, and I am currently undertaking an in-depth assessment of what needs to be done to truly maintain world-class facilities. My office has recently completed an inventory of all Army laboratory facilities, and in consultation with facilities experts in the Research, Development and Engineering Command and the United States Army Corps of Engineers we are developing a Statement of Work for a team to inspect the roughly 1,000 Army S&T facilities. One outshoot of this facilities survey will be a new MILCON requirements list for Army labs. With the support of the Committee, our labs and centers are now able to spend a portion of their funding on minor military construction projects. While this authority has been helpful, it is not enough, and we are still faced with the difficulty of competing for scarce military construction dollars at the levels needed to properly maintain world-class research facilities. This will be one of our major challenges in the years to come and I look forward to working with OSD and Congress to find a solution to this issue.

Finally, the Army S&T enterprise cannot survive without developing the next generation of scientists and engineers. We are lucky to have an amazing group of young scientists and engineers to serve as role models for the next generation. Last year, Dr. Tad Brunye, a Natick Soldier Research, Development and Engineering Center Cognitive Science researcher, was named by President Obama as one of the nation's Outstanding Early Career Scientists. The Presidential Early Career Awards for Scientists and Engineers are the highest honor bestowed by the United States government on science and engineering

professionals in the early stages of their independent research careers, and we are lucky to have researchers like Dr. Brunye to mentor the next generation.

Army S&T contributes to the future success in Science, Technology, Engineering and Math (STEM) education through the Army Educational Outreach Program (AEOP) which comprises 17 outreach efforts, either through direct oversight or through active participation. In the 2010-2011 academic year AEOP received over 15,592 student online applications, engaged nearly 27,000 students as well as 984 teachers, involved 141 universities and utilized the experience and personal commitment many of our Army scientists and engineers. The Army Educational Cooperative Agreement (COA) brought together government and a consortium of organizations working collaboratively to further STEM education and outreach efforts nationwide in its first year of operations. Major accomplishments included an in-depth evaluative assessment of six programs and recommendations for evidence-based program improvements. An additional thrust is the enhancement of the online, comprehensive application tool located on the AEOP website. The application tool will provide important data that assess attitudes, motivation, qualifications, and experiences that gauge program effectiveness. The website and the online application tool as well as the COA will work together to provide a coherent and coordinated approach to address the STEM workforce shortfall throughout the Army. For FY2013, we are concentrating on further program assessment, implementing evidence-based program improvements, and identifying ways to expand the reach and influence of successful existing programs by leveraging partnerships and resources with other services, agencies, industry and academia.

These are exciting and challenging times for the Army's S&T program. We are changing the Army S&T business model to be an enduring, sustainable, successful enterprise, and aligning our strategic planning to the budget process to achieve efficient, top-down S&T leadership investment focus. We are identifying critical Army problems that we can solve in the near and mid-term, using the best talent and skills wherever they exist. Finally, we are enhancing the visibility of Army S&T priorities to provide partnering opportunities to jointly solve problems and enhance our Warfighter capabilities. As you can imagine, this is a tremendous undertaking, and would not be possible with the support we have received from Congress. I hope that we can continue to count on support as we move forward, and I would like to again thank the members of the Committee again for all you do for our Soldiers. I would be happy to take any questions you have.

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Deputy Assistant Secretary for Research & Technology (SAAL-ZT)

Dr. Marilyn Miller Freeman

Dr. Marilyn M. Freeman was designated as the Deputy Assistant Secretary for Research and Technology in July 2010. Dr. Freeman is responsible for the entirety of the Army's Research and Technology program, spanning 21 Laboratories and Research, Development and Engineering Centers, with more than 10,000 scientists and engineers and a yearly budget of nearly $2 billion dedicated to empowering, unburdening and protecting Soldiers. Previously, Dr. Freeman served as the Director of the US Army Natick Soldier Research, Development and Engineering Center.

CAREER CHRONOLOGY:

- Sep 2007 –Jul 2010 Director of the US Army Natick Soldier Research, Development and Engineering Center.
- Sep 2007 –Selected to the Senior Executive Service ; appointed to the position as the Director of the US Army Natick Soldier Research, Development and Engineering Center.
- Oct 2006 – Sep 2007: Deputy for Technologies, Office of the Deputy Assistant Secretary of the Army for Research and Technology, Washington, DC
- Oct 2005 – Sep 2006: Technical Director (Acting), US Army Tank Automotive Research, Development and Engineering Center, Warren, MI
- Oct 2001 – Sep 2005: Deputy for Armament, Vehicle and Soldier Technologies, Office of the Deputy Assistant Secretary of the Army for Research and Technology, Washington, DC
- May 2001 – Sep 2001: Technical Director, Future Combat Systems, Defense Advanced Research Projects Agency, Arlington, VA
- Sep 1998 – Apr 2001: Program Manager, Combat Hybrid Systems Program, Defense Advanced Research Projects Agency, Arlington, VA
- Oct 1997 – Aug 1998: Special Assistant to Associate Director for Technology, Army Research Laboratory, Adelphi, MD
- Aug 1996 – Sep 1997: Liaison, Office of the Director of Research, Office of the Deputy Assistant Secretary of the Army for Research and Technology, Washington, DC
- Aug 1990 – Jul 1996: Army Liaison, Electric Armaments Program, University of Texas at Austin, TX
- Apr 1981 – Jul 1990: Senior Scientist, US Army Armaments Research, Development and Engineering Center, Picatinny Arsenal, NJ

EDUCATION:

- PhD, Materials Science and Engineering, The University of Texas at Austin, Austin, TX, 1996
- MS, Materials Science, Stevens Institute of Technology, Hoboken, NJ, 1990
- BS, Physical Science, University of Dayton, Dayton, OH, 1975

CERTIFICATIONS:

- Level III, Army Acquisition Corps, Systems Planning, Research, Development and Engineering

PROFESSIONAL MEMBERSHIPS AND ASSOCIATIONS:

- Association of the United States Army

MAJOR PUBLICATIONS:

- Dissertation, Effect of Defects on Breakdown of Dielectric Materials, 1996

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EMERGING THREATS AND CAPABILITIES SUBCOMMITTEE

STATEMENT OF
REAR ADMIRAL MATTHEW L. KLUNDER, UNITED STATES NAVY
CHIEF OF NAVAL RESEARCH

BEFORE THE
EMERGING THREATS AND CAPABILITIES SUBCOMMITTEE
OF THE
HOUSE ARMED SERVICES COMMITTEE
ON
THE FISCAL YEAR 2013 BUDGET REQUEST

FEBRUARY 29, 2012

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EMERGING THREATS AND CAPABILITIES SUBCOMMITTEE

Introduction

It is an honor to appear before you to report on Science and Technology (S&T) efforts within the Department of the Navy (DoN) and discuss how the President's FY 2013 Budget supports the Navy and Marine Corps (USMC). The President's FY 2013 Budget requests approximately $2 billion for Naval S&T.

From the beginning of this nation, the Navy and Marine Corps have leveraged innovation and technology to defend U.S. interests. To ensure continued superiority of U.S. Naval forces after World War II, congress established the Office of Naval Research (ONR) to "plan, foster and encourage scientific research in recognition of its paramount importance to future Naval power and national security." Our Naval S&T objective is to support a Navy and Marine Corps capable of prevailing in any environment. We work directly with the Secretary of the Navy (SECNAV), Chief of Naval Operations (CNO) and Commandant of the Marine Corps (CMC) to achieve this goal by: 1) focusing on S&T areas with big payoffs, 2) encouraging innovative thinking and business processes, and 3) constantly striving to improve transition of S&T into acquisition programs in the most cost-effective means possible. In the spirit of striving for affordability, we must strike the right balance between responsive near-term technology insertion and long-term basic research.

SECNAV priorities include: 1) care of Sailors, Marines, Civilians and families, 2) treating Navy energy requirements as issues of national security, 3) achieving acquisition excellence, and 4) optimizing unmanned systems. We support those priorities by implementing CNO and CMC guidance in the application of S&T resources. In addition, we constantly strive to improve communication and constructive engagement with stakeholders.

Science and Technology Strategic Plan

The Naval Science and Technology Strategic Plan was developed to guide S&T investments and is regularly reviewed by Navy and USMC leadership to affirm the alignment of Naval S&T with current missions and future requirements. It ensures S&T has long-term focus, meets near-term objectives, and makes what we are doing clear to decision makers, S&T partners, customers and performers.

Our focus areas guide investments in corresponding research areas. The recently revised S&T Plan identifies nine focus areas where S&T investments support Navy and USMC requirements: 1) Assure Access to Maritime Battlespace, 2) Autonomy and Unmanned Systems, 3) Expeditionary and Irregular Warfare, 4) Information Dominance, 5) Platform Design and Survivability, 6) Power and Energy, 7) Power Projection and Integrated Defense, 8) Total Ownership Cost, and 9) Warfighter Performance. These nine areas represent an evolving consolidation developed from Naval needs, sized for reasonable scale and magnitude, and linked directly to warfighting functions.

In each area, our goal is to move from existing systems and concepts of operations toward a warfighting capability to counter predicted threats in an increasingly complex and uncertain environment. It is the challenge we face as the proliferation of anti-access, area-denial (A2/AD)

capacity and capabilities among potential adversaries drives the need for technologies that assure access for Naval forces. While the starting point is continued evolution of current systems, we progress toward incremental improvements and spiral development of known technologies – to new development of undiscovered, disruptive technologies. If we are good, and perhaps lucky, this is where today's S&T encounters the unanticipated future.

Implementing the Strategy

We execute Basic Research (6.1) thru Advanced Technology Development (6.3) funds by dividing S&T into four primary areas – Discovery and Invention (D&I), Leap Ahead Innovations (Innovative Naval Prototypes), Acquisition Enablers (Future Naval Capabilities), and a Quick Reaction capability to respond to emerging emergency requirements. As we review and revise plans, the changes reflect our continuing efforts to communicate more effectively, as well as to clarify, streamline and respond more efficiently to Fleet/Force requirements. Our portfolio balances a range of complimentary but competing imperatives, in that we support advances and initiatives in established operational areas – while maintaining a far-reaching complement of long-term research efforts that may prove disruptive to traditional operational concepts.

Discovery and Invention

Discovery and Invention (D&I) includes basic research (6.1) and early applied research (6.2) in areas with unique requirements essential to Naval missions, but also in areas that are undefined but hold promise for future application. D&I develops fundamental knowledge, provides the basis for future Navy/Marine Corps systems, and keeps our Scientist and Engineer workforce relevant. Research areas include autonomous sciences, computational neuroscience, bio-inspired sciences, information technology, cognitive/neural training technologies, advanced quantum computing, materials sciences (acoustic metamaterials, integrated computational material sciences, nano-manufacturing), and counter Improvised Explosive Device (IED) sciences. Work in these areas led to 61 Nobel Prizes for ONR researchers.

Approximately 45 percent of ONR S&T investment is D&I. We assess impact on Navy/Marine Corps missions, as well as potential for innovative performance, in order to invest resources in the best research areas and projects. This develops a broad base of scientific knowledge from which INP, FNC, and quick reaction efforts are generated. Approximately 60 percent of basic research is executed with academic and non-profit performers, with all programs peer reviewed during the second to third year from inception to ensure high quality and integrity. Peer review is conducted by outside scientific and technical experts who provide an independent assessment of the scientific merit of the research being conducted, with results reviewed by ONR program officers, division directors, department heads and senior leadership. Significance and originality, scientific merit and accomplishment, risk and potential impact, the principal investigator, and budget resources are all evaluated, with adjustments made in programs as appropriate.

An important element of D&I is the Defense University Research Instrumentation Program (DURIP), which supports university research essential to Naval research. DURIP complements our D&I programs by supporting purchases of high cost instrumentation necessary to carry out cutting-edge research. ONR awarded 68 DURIP grants in FY 2007, 92 in FY 2008, 82 in FY

2009, 61 in FY 2010, 64 in FY 2011, and plans to award approximately 94 grants in FY 2012. Another D&I program, ONR's Basic Research Challenge, stimulates interdisciplinary research in emerging S&T fields by funding promising research in areas not addressed by the current basic program.

D&I investments develop and invigorate the S&T workforce and support Science, Technology, Engineering and Mathematics (STEM) outreach. Through Independent Laboratory In-house Research (ILIR) and Independent Applied Research (IAR) programs, ONR sponsors critical research, while furthering education of scientists and engineers at Warfare Centers. Education and research opportunities for undergraduate and graduate students, fellows, and future faculty members and researchers are provided through programs such as the Naval Research Enterprise Internship Program (NREIP), which expose participants to work at Naval laboratories and warfare centers.

Through the University Research Initiative (URI) and Young Investigators Program (YIP), ONR gains access to researchers with a willingness to investigate high priority topics of interest to the Naval services. Through our Multidisciplinary University Research Initiative (MURI), ONR supports multi-disciplinary university teams to speed scientific progress by cross-fertilization of ideas, hasten transition of basic research to practical applications, and train students in cross-disciplinary approaches to science and engineering research of importance to DoD. We also support the Presidential Early Career Award for Scientists and Engineers (PECASE), honoring achievements of young professionals at the outset of independent research careers in S&T. Through demonstration, apprentice, award, and graduate programs, we encourage young people to explore S&T careers in academia, Naval laboratories, and industry.

Nowhere is our support for educational initiative and academic excellence more evident than in ONR's partnership with Historically Black Colleges and Universities and Minority Institutions (HBCU/MI). ONR educational and research partnerships bring together Naval laboratories and warfare centers with dozens of HBCU/MIs, giving hundreds of students an opportunity to have hands-on experience in the Naval research environment. The progression from undergraduate to graduate partnerships, and mentoring by Naval scientists and engineers, resulted, for example, in 33 Tuskegee University graduates being currently employed by Naval Sea Systems Command (NAVSEA) laboratories. Similar examples abound in other Navy labs and warfare centers, with every graduate employed by the Navy representing a success story that we want to duplicate as many times as possible.

ONR is a great place to work, and in the HBCU/MI context, we were recognized as a "2011 Best Diversity Company" by readers of *Diversity/Careers in Engineering & Information Technology* magazine. ONR was selected from over 100 U.S. corporations and government agencies as a leader in workplace diversity, and recognized for its support of minorities and women, attention to work-life balance, and commitment to supplier diversity. In 2011 ONR was also selected as a Top Supporter of HBCU Engineering Schools by *U.S. Black Engineer & Information Technology* magazine. We will not rest on our laurels with respect to earning these honors.

Science, Technology, Engineering and Mathematics (STEM)

Our Navy and Marine Corps ability to support the warfighter depends on our ability to sustain both technology development and a Science, Technology, Engineering and Mathematics (STEM) workforce. We believe the key to achieving this goal lies in supporting STEM education in a continuum of experiences from kindergarten through post-doctoral opportunities. The Department of the Navy is concerned that the number of U.S. STEM graduates will not keep up with our future demand or the increased international competition for that same talent.

China awards nearly three times as many engineering and computer science degrees as the U.S., and surpasses us in the number of STEM-related Ph.D. graduates. Currently, only fifteen percent of bachelor's degrees earned by U.S. students are in STEM fields. Also, if one looks at the breakdown of students receiving STEM degrees, the number of underrepresented minorities and women does not reflect the demographics of our nation. Further, at the K-12 level, our students rank 20th place as compared to STEM students in other industrialized countries. Given that we expect an increased demand for U.S. personnel in STEM fields in the future, these trends threaten not only America's economic security, they directly impact our ability to deliver the most advanced technologies to our warfighters. These negative trends must be addressed now.

The purpose of the Navy's STEM program is to help reverse these negative trends and ensure a strong, STEM-literate Naval workforce in the future. These professionals are a key to innovation and are critical to maintaining the Navy's S&T strength. Because of our previous initiatives and leadership, in 2009 ONR was tasked with coordinating Naval STEM educational and outreach activities. This led to the 2009 launch of STEM2Stern.org, an on-line collaboration resource for information about Naval STEM programs and how to get involved. Managed by ONR, the Naval STEM Coordination Office provides a cohesive approach to STEM education and outreach across the service laboratories and Warfare Centers. This effort helps leverage funding, duplicate successful efforts, broaden the reach and scope of our most impactful STEM programs, and evaluate their impact and return on investment.

Through our strongly coordinated and leveraged STEM program, the Navy is making critical contributions aimed at strengthening America's competitive edge, and ensuring a sufficient talent pool exists to support future Naval technical needs. In an effort to leverage expertise from across the STEM field, ONR hosted a Naval STEM Forum last June that assembled over 750 leaders from the Navy, industry, academia and nonprofits to share best practices and discuss ways to partner with the DoN on STEM initiatives.

Ultimately, the goal of Naval STEM is to increase the talent pool of future Sailors, Marines, Naval scientists and engineers. Our current S&T workforce is aging. Nearly 65% of DoN science and engineering professionals are over the age of 40, and over 50% will be retirement eligible by 2020. Even more alarming, according to a recent study done for NAVSEA, 40 percent of their Naval architects and 30 percent of their Naval engineers will be retirement eligible by 2014. That is just two years from now. Because the Navy's S&E workforce is comprised mostly of engineers, this is where a potential shortfall could lie for the Navy – particularly in Navy-relevant fields such as naval engineering, computer science and ocean engineering. Unfortunately, the U.S. production of engineers has remained flat over the last two

decades at just over 6%, and in these specialty fields it is far less. Further complicating our workforce challenges is the fact that for security reasons, the DoN must rely on U.S. citizens for classified technology work.

ONR/NRL investments total nearly 70% of overall Naval investments in STEM. SECNAV committed to doubling Naval STEM investments by FY 2015. In FY 2010, the Navy's STEM portfolio included education and outreach efforts across 31 commands, reaching over 69,000 participants across the country, leveraging a direct investment of $42 million, and an additional $32 million from OSD and the National Defense Education Program (NDEP). Our investments seek to increase the diversity and numbers of students pursuing STEM degrees though programs, which encourage collaboration among the government and best practice organizations, universities and industry. Our areas of emphasis include: 1) freshman and sophomore STEM retention in college, 2) hands-on STEM learning programs in urban and rural middle schools, 3) teacher training in Naval-relevant fields of study, and 4) mission-critical graduate student and post-doctoral support. Our newest programs incorporate both Naval relevant content and metrics for measuring impact, and will be coordinated with other Federal STEM education programs. Further, these programs were selected based on their potential for rapid growth and geographic expansion, as well as their ability to serve underrepresented student populations.

Naval STEM education and outreach programs include an array of Hands-On programs, Competitions, Internships, Research Fellowships, and Teacher Training. Many students – particularly those from underserved populations (including minorities, females, and students from urban and rural settings) make decisions by the end of middle school to opt out of STEM education. It is therefore critical to engage students no later than middle school by offering them a variety of hands-on learning opportunities and mentoring experiences, building their STEM confidence and encouraging them to pursue the math and science classes needed to make them STEM eligible in college.

In grades K-6, we support programs such as: Iridescent, SeaPerch, and FIRST Robotics. At the high school level, our programs include the National Math & Science Initiative, Science and Engineering Apprentice Programs, Youth Exploring Science (YES), the National Ocean Sciences Bowl, and Naval Science Awards Programs. Our college efforts offer the Naval Research Enterprise Internship Program, Autonomous Underwater Vehicle (AUV) Competition, the Naval Postgraduate School Hartnell Internship Program, and the University Laboratory Initiative (ULI) Program. Post-doctoral opportunities include the Young Investigator Program and University Research Initiative (URI) efforts. Across this spectrum of STEM education, teacher training and education tools are also being developed to strengthen in-classroom and out-of classroom STEM programming. Providing these necessary tools and training to teachers and educators strengthens their expertise, while enabling them to link Naval themes and content to curriculum goals.

Naval STEM ensures continued access to a variety of Navy-unique STEM professionals and locations. In 2010, Naval Sea System Command Warfare Centers supported more than 16,500 students and 800 teachers through in-school and summer camp STEM events. Space and Naval Warfare Systems Command scientists and engineers volunteered more than 10,000 hours in K-12 student communities. Naval Air Systems Command reached 16,000 students and 700

teachers through engineering challenges, speaker bureaus, summer camps, student employment and teacher training.

It is important to point out that this investment can only be justified if we are improving our future workforce. For many of these investments, we may not be able to see that return for many years to come. However, individually and collectively, we are assessing each to best determine how each one contributes to achieving the Navy's goals and how it impacts each stage of the pipeline. Therefore, as we move forward in 2012, we will ensure that a comprehensive evaluation and metrics plan is put in place for all of our STEM programs, one which measures not only the numbers of students and teachers we are reaching but one that also assessing our ability to fulfill our future Naval requirements.

One of our proudest achievements last year was the 49th National Junior Science and Humanities Symposium held in San Diego, California, jointly sponsored by the Air Force, Army, and Navy. Research topics included: acoustics and noise abatement, environmental science (including biodiversity and marine fouling), alternative energy production (including biofuels, solar cells, solar fuel production and aerodynamics of wind turbines), medical and health care (including cancer research and hearing loss), nanotechnology, robotics, rocket motor efficiency, satellite system design, thermodynamic analysis of engine design, design of underwater vehicles, and use of autonomous Unmanned Aerial Vehicles in search and rescue operations. These topics mirror many research topics in which ONR is currently investing.

Scientific papers were presented by, among others, Jonathan Ang, Arjun Balasingam, Mark Becker, Paul Bergin, Connor Berlin, Shyamal Buch, Alexander Chen, Junyoung Choi, Victor Duan, Clara Fannjiang, Margo Fendrich, Katlyn Firkus, Anisha Garg, Andrew Giviansky, Sarah Hardtke, Victoria Huang, Erik Kemp, Swathi Krishnan, Arti Kumar, Vignessh Kumar, Won Lee, Jonathan Li, Wenxi (Sheryl) Li, Yifan Li, Daniel Liss, Anna Maika Manalad, Austen Mance, Sage Mandel, Lisa Michaels, Sophie Miller, Apexa Modi, Hilary Mogul, Paimon Pakzad, Kira Powell, Andrew Raffa, Emma Rose, Himanshu Savardekar, Prem Thottumkara, Haoxuan Wang, Max Wasserman, Zachary Wood, and Jeremy Wortzel.

Every one of these students attended high school in your congressional districts last year. You may not recognize their names today, but our successors in government, in the S&T community and in the Navy will know them because great S&T research achievements lie ahead for them in the future. There is a good a chance that they will lend a competitive edge to this nation, and some may perform research and make new discoveries we simply cannot imagine that save the lives of their fellow graduates who left high school or college to serve in the Navy and Marine Corps. That's what our STEM effort is all about – exploring innovative and exciting ways to attract high quality talent into our labs and warfare centers and raising the general STEM level of achievement throughout our nation.

Leap Ahead Innovations (Innovative Naval Prototypes)

Innovative Naval Prototypes (INP) involve approximately 12 percent of the S&T budget and focus on high-risk/high-payoff opportunities emerging from the D&I portfolio that can significantly impact Naval capabilities if we can mature the technology. INPs are discontinuous,

disruptive, radical departures from established requirements and operational concepts. Approved and overseen by the Naval S&T Corporate Board (Assistant Secretary of the Navy for Research, Development and Acquisition (RD&A), Assistant Commandant of the Marine Corps and Vice Chief of Naval Operations), the goal is to prove concepts and mature technology within 4-8 years, allowing informed decisions about risk reduction and transition into acquisition programs. In order to facilitate transition to acquisition programs, Program Managers are primarily selected from ONR, with Deputy Program Managers typically chosen from the Acquisition community.

With the Persistent Littoral Undersea Surveillance (PLUS) INP (to develop an autonomous over-the-horizon Anti-Submarine Warfare system) and Sea Base Enablers INP (to evaluate Transformation Craft concepts) completed last year and elements of both transitioning to the Fleet/Force, we have five current INPs:

The Electromagnetic Rail Gun (EMRG) INP continues to develop and test a scalable, more powerful gun, using non-explosive rounds with no gun propellant. The EMRG has more than doubled current state of the art muzzle energy. The program continues to achieve its technical objectives and ONR has initiated Phase Two of the program. EMRG will provide multi-mission capability for long range, persistent, precision fire without unexploded ordnance issues, while increasing magazine capacity, and decreasing total cost. If current research goes as anticipated, projectiles will initially fire at targets up to 100 nautical miles away, and eventually fire at a muzzle velocity of Mach 7.5 and reach targets 200+ nautical miles away in less than six minutes, impacting at a velocity exceeding Mach 5. The Navy is planning to deliver a multi-mission capability to include Naval surface fire support, Anti-Surface Warfare and self defense applications with nearer term capability against cruise missiles and other targets of interest. Ship integration studies for various platforms have been performed including the DDG51. Contractors have built and tested pre-prototype tactical launchers, and the first full scale contractor built prototype was delivered to the Naval Surface Warfare Center at Dahlgren, Virginia in January of this year. I join my predecessors in inviting you to schedule a visit to our facility at Dahlgren and am grateful to your staff members who have already made the visit. Our discussions with your staff during the FY 2012 authorization process led to refinements in the program and planning about which the SECNAV and I will be reporting to you as directed by the FY 2012 National Defense Authorization Act.

The Free Electron Laser (FEL) INP will develop the critical technologies needed for a Megawatt class laser system. The FEL can be designed to be tunable to atmosphere-penetrating wavelengths for use in maritime environments. Focusing on the critical components will allow us to assess the potential of fielding a Megawatt class laser on a surface ship, which will permit additional shipboard sensors and defense that includes tracking, discrimination, countermeasures, and scalable direct fire at the speed of light. Because of its potential to reach Megawatt power levels, the FEL is designed to defend against current and future surface and air threats, anti-ship cruise missiles, small boat swarms, and other asymmetric threats. As concepts of operations, missions and host platforms are refined, so are ONR priorities about laser research investments. Our discussions within the Navy and with your staff during the FY 2012 authorization process led to refinements in the program which we intend to implement this year, including maturation of Solid State Laser Technology. We are determined to put the right laser on the right platform.

The Integrated Topside INP will enable Navy to dominate the electromagnetic spectrum through development of multi-simultaneous function wide-band apertures and Radio Frequency (RF) equipment for all ship classes. We are developing advanced Electronic Warfare, Information Operations, Radar, Satellite and Line of Sight Communication systems using: 1) open architecture for RF equipment, plus computer hardware and software that will enable industry to contribute to development of affordable new systems and upgrades, and 2) modular systems that enable the same technology to be scalable across all Naval platforms to significantly reduce logistics, training, and maintenance costs. FY 2013 will see prototype tests and demonstrations at government and contractor test facilities in Maryland, New Jersey, New York, Rhode Island, Texas, and at the Naval Research Laboratory (NRL).

The Large Displacement Unmanned Undersea Vehicle (LDUUV) INP is developing a reliable, long endurance UUV capable of extended operation in cluttered littoral environments. The program will develop the needed energy, autonomy and core UUV systems to operate in a complex ocean environment near harbors, shore, and high surface traffic locations. Key goals include doubling current UUV energy density, and using open architecture to lower costs, while enabling full autonomy in over the horizon operations. Achieving these goals will reduce Naval platform vulnerability, while enhancing warfighter capability and closing capacity gaps in critical mission areas. During FY 2013 sea trials, we will develop autonomous behaviors and integrate battery and fuel cell power systems. Reliability will be demonstrated by a series of longer endurance tests with goals in excess of three weeks.

The Autonomous Aerial Cargo/Utility System (AACUS) INP is developing intelligent, autonomous capabilities for an aerial cargo/utility system that can provide rapid, affordable, and reliable rotorcraft supply and retrograde. Challenges include dynamic mission management and contingency planning, as well as landing zone location and landing execution under demanding conditions. Potential solutions involve modular capabilities developed in an open system architecture, novel human interfaces (to include optional manning), low impact (size, weight, power, and cost) sensors, and multiple flight demonstration and upgrade cycles.

In addition to INPs, SwampWorks programs, although similarly high-risk and disruptive, are smaller than INPs and intended to produce results in 1 to 3 years. SwampWorks efforts have substantial flexibility in planning and execution, with a streamlined approval process shortening the innovation cycle. Although a formal transition agreement is not required, SwampWorks programs have strong advocacy outside ONR, either from the acquisition community or Fleet. SwampWorks products are frequently inserted into Fleet experimentation and, if successful, can provide impetus for new acquisition requirements.

Acquisition Enablers (Future Naval Capabilities)

Acquisition Enablers (AE) are the most critical component of our transition strategy. Most of the AE portfolio consists of our Future Naval Capabilities (FNC) program, with the remainder including USMC Advanced Technology Development (6.3) funds, Joint Non-Lethal Weapons Directorate 6.3 funds, the Manufacturing Technology (ManTech) program, and the majority of Low Observable, Counter Low Observable funds.

FNCs are near-term projects and represent the requirements-driven, delivery-oriented portion of the Naval S&T portfolio. The FNC process delivers mature technologies to acquisition sponsors for incorporation into systems that provide new capabilities to the warfighter.

FNC investments employ a collaborative process involving requirements, research, acquisition, and Fleet/Force communities to align the requirements-driven portion of the S&T portfolio with Naval Capability Gaps identified by the Office of the Chief of Naval Operations (OPNAV) and Marine Corps Combat Development Command (MCCDC). A gap is any capability required to achieve Naval objectives that is not achievable with current platforms, weapon systems, doctrine, organizational structure, training, materials, leadership, personnel or facilities and requires S&T investment to solve or overcome. Capability Gaps define the requirement but not how to meet it.

FNC projects are selected annually to address specific gaps, with final prioritization approved by a 3-Star Technology Oversight Group (TOG) representing OPNAV, United States Marine Corps (USMC), U.S. Fleet Forces Command (USFF), Assistant Secretary of the Navy (ASN-RDA) and ONR. FNCs are based on D&I investments where technology can be matured from Technology Readiness Level (TRL) 3 to TRL 6 within five years. Selection takes into account related work in the Defense Department (DoD), other government agencies, industry and Naval centers of excellence.

Approved technology products are required to have Technology Transition Agreements that document the commitment of the resource sponsor, acquisition program, and ONR to develop, deliver and integrate products into new or upgraded systems to be delivered to the Fleet/Force. Every FNC product is annually measured against technical and financial milestones. All FNC products must meet required transition commitment levels for S&T development to continue. This practice helps make every dollar count. Products that no longer have viable transition paths are terminated with residual funding used to solve problems with existing projects, or start new projects in compliance with Navy priorities, charters, business rules and development guidelines.

The measure of FNC success is whether projects meet technology requirements and exit criteria, and whether acquisition sponsors have transition funds in their programs to accept and integrate FNC products. Products with planned transition funds usually transition after risks are mitigated, a definitive plan finalized, and required funding programmed.

FNC Funding

As has been stated by my predecessors, our investments focus on the most pressing capability gaps, generating year-to-year changes in funding for FNC products based on successful transitions, reprioritization, new starts, and evolving Naval needs and requirements. As FNC products mature, Technology Readiness Levels (TRL) change, moving products from 6.2 to 6.3 PEs. Year one is predominantly 6.2; the final year predominantly 6.3 – with a mix of 6.2/6.3 in-between. When products transition to Advanced Component Development and Prototypes (6.4) and Engineering and Manufacturing Development (6.5) funding, responsibility for continued development shifts from ONR to the acquisition commands. We believe changes in this year's PE structure make realignment of FNC funding more understandable and transparent, and provide a more cost-effective and responsive framework for renewing FNCs. We will work with

you and your staff to ensure that this realignment does not result in any loss of visibility for the FNC program.

Quick Reaction S&T

In addition to Discovery and Invention, Leap Ahead Innovations, and Acquisition Enablers, ONR maintains a capability to initiate quick-reaction projects over a period of 12 to 24 months that respond to immediate needs or compelling innovations identified by Fleet/Force or Naval leadership. TechSolutions provides rapid short-term S&T solutions to immediate operational and tactical requirements. Accessible through Internet and SIPRnet, TechSolutions accepts recommendations from Sailors and Marines working at the tactical level on ways to improve mission effectiveness through the application of technology. TechSolutions uses rapid prototyping of technologies to meet specific requirements. Each project is structured with definable metrics and appropriate acquisition and test systems command elements in an integrated product team concept. While neither a substitute for the acquisition process nor a replacement for systems commands, TechSolutions provides the Fleet/Force with prototypes that deliver solutions to address immediate needs that can be easily transitioned by the acquisition community.

The basic problem we are trying to solve is that the pace of technology development is often faster than the DoD Planning, Programming, Budgeting and Execution (PPBE) process can respond. Our Rapid Technology Transition (RTT) and Technology Insertion for Program Savings (TIPS) programs are structured to provide current-year funding (inside the PPBE process), eliminating the up to 2 year time lag inherent in the PPBE cycle. The general scope of each program is funding up to $2 million for development efforts taking no more than two years to complete, strong Fleet/Force support, and resource sponsor commitment to fund costs to transition the technology into the acquisition Program of Record (POR) or operating system. The RTT program focuses on providing incremental, timely improvements to an acquisition POR. The TIPS program focuses on providing timely improvement which substantially reduces operating and support costs for warfighting systems. Congress has been very supportive of this concept.

In addition, and in partnership with ONR, the Naval Warfare Development Command (NWDC), Naval Postgraduate School, Naval War College and Marine Corps Warfighting Lab (MCWL) explore future warfighting concepts and evaluate emerging technologies. Initiatives and ideas in support of our overall maritime strategy are applied, tested, analyzed and refined through war games, exercises, experiments and operational lessons learned. For example, in support of those efforts, Commander, U.S. Fleet Forces Command, in coordination with Commander, U.S. Pacific Fleet, leads the Fleet-Led Experimentation (FLEX) program, a continuous process of operational and tactical experimentation.

S&T Highlights

The Naval S&T portfolio includes specific projects entering the Fleet/Force or about to enter in a short time, as well as a range of supporting programs. Following are examples of these efforts outlining the impact they will have on Sailors and Marines, today and in the future.

Common Information Environment for Combat Systems (CS); Command and Control (C2) Systems; and Intelligence, Surveillance, and Reconnaissance (ISR) Systems

ONR supports a broad effort to integrate the many disparate, independent CS, C2, and ISR systems into a common information environment architecture that is modular and based on open standards. The goal is to automate analysis of large amounts of data, reduce manpower requirements, and provide technical solutions and direction to related acquisition programs.

Navy and DoD systems are often point solutions with serious data and system interoperability issues. They tend to be proprietary closed systems which are costly to maintain and upgrade. However, ONR, in partnership with Program Executive Office for Command, Control, Communications, Computers and Intelligence (PEO C4I), developed an open source Service Oriented Architecture (SOA) as the foundation for next generation C2 systems. Operational use of this system began in 2006 when a core component was installed aboard CVN-76 (USS Ronald Reagan) to support the Maritime Domain Awareness system.

The SOA provided infrastructure for the C2 Rapid Prototype Continuum (C2RPC) system deployed at Pacific Fleet's request for use in Maritime Operational Center readiness analysis. Readiness analysis formerly required multiple personnel days to accomplish. C2RPC performed this analysis in a matter of hours (over 1400 times faster than manual processes), resulting in it being moved to the watch floor for use in operational planning while still an S&T prototype.

In 2010, the highly adaptable C2RPC SOA enabled additional capabilities and applications which led to installation requests by 5th, 6th, and 7th Fleets. The Air Force's (USAF) Air and Space Operations Center – Weapons System (AOS-WS) is evaluating this system for their use. In turn, USAF information services were directly integrated into the SOA framework, with both Services benefiting from capabilities each developed. This effort also transitioned to Navy's Afloat Core Services (ACS) Program of Record (POR) in Consolidated Afloat Networks and Enterprise Services (CANES).

Another application that resulted in major reductions in manpower and time required to deliver information is a C2RPC application that provides C2 of Intelligence. This prototype application is hosted on networks being evaluated by the Commander, Pacific Fleet, Naval Intelligence (CPF N2) watch team staff for automating theater collection assets as mapped to operational platforms and targets. The premise is to build an all-source collections awareness and decision assessment tool suite for theater intelligence management. The tool suite can be tailored and automated to support intelligence nodes at the theater, operational and tactical levels. As automated software matured, the CPF N2 staff realized they could delegate watch duties from O-3 ranks to the E-3/4 level – and eliminated four watch personnel from the daily rotation structure. C2 intelligence status can be obtained by pressing a print button as opposed to 10 man-hours per day.

The next aspect of the effort began in FY 10 with a Limited Technology Experiment to develop the capability to automate generic sharing of information across combat and SOA C2 systems – with emphasis on Anti-Submarine Warfare (ASW). This experiment was conducted with full participation of PEO Integrated Warfare Systems (IWS) and PEO C4I to ensure experimentation

directly addressed critical risks and ensure rapid transition to the Advanced Capability Build (ACB) POR and the CANES POR.

The initial FY 10 experiment demonstrated the transfer of information from the combat system to the Afloat Core Services (ACS) C2 system, with data transfer across platforms accomplished through the Advanced Digital Network System (ADNS) Extremely High Frequency (EHF) Time Division Multiple Access Interface Processor (TIP). The initial experiment met information assurance and latency requirements for the combat system, successfully demonstrated the capability, and helped identify shortfalls that need to be addressed.

In December 2011 we just completed addressing these issues, as well as those required to demonstrate transfer of information from C2 system to combat system. Navy, USAF and Army are conducting joint experimentation involving automated and continuous air, land, and surface battle-space de-confliction utilizing this framework. This will enable rapid Naval fire support and direct machine-to-machine information transfer for joint targeting.

Future plans include:

1) A C2-ISR version of C2RPC will be placed at Joint Interagency Task Force South (JIATF-S) to test and evaluate strategies, algorithms, and hypotheses supportive of planning, execution, and reviewing ISR operations. JIATF-S provides critical opportunities to work with very large, highly disparate data sources, including sensors and soft data, on a continuous basis in a multi-organization environment. This mirrors DoD operations with allies, partners, and non-governmental organizations where similar security issues must be addressed.

2) Experiments will be performed to enable common control of multiple, disparate unmanned ISR vehicles, automated information exchange, and manpower reduction in the management of the overall distributed system. In contrast to the current point solution with costly acquisition, lack of interoperability, and expensive logistics overhead, this effort will include multiple PEOs, ensuring that S&T provides a common approach across multiple acquisition communities.

3) A joint Navy Expeditionary/Marine Corps effort will develop S&T needed to enable riverine forces and Marine squads to significantly reduce Unmanned Aerial Vehicle (UAV) manpower requirements. UAVs utilized by these forces sometimes require so many people to operate and analyze data that combat units don't have sufficient manpower left to exploit emerging tactical opportunities. This effort will address the problem by automating management of a group of unmanned sensor platforms to provide coverage of a 400 square mile area, while simultaneously tracking at least 300 objects and activities of interest.

The overall impact of this broad effort is to develop a highly flexible, open architecture information and decision making capability with applications enabling operational and tactical forces to function with the same distributed information base across all warfare and mission areas. Information gathering and analysis will be largely automated and autonomously controlled so the warfighters can identify valuable time to make decisions and execute plans.

At a fraction of the cost, these efforts succeed where past efforts failed because traditional acquisition approaches issued contracts for proprietary solutions developed by single contractors. However, the SOA approach is unique in using industry and government performers to develop open source, open architecture solutions in an environment where government owns unrestricted licensing rights, and best of breed technologies for various modules individually competed and funded. Equally important, S&T is developed hand-in-hand with acquisition and requirements communities and evaluated by Fleet/Force through numerous Limited Technology Experiments. S&T prototypes are deployed in operational environments for first-hand evaluation, assessment, and Fleet feed-back. This accounts for significant improvement in transition results.

Irregular Warfare, Unmanned Systems, Medical Care

In addition to our dominance of the communications, information and cyber warfare spectrum, ONR's research portfolio reaches into depths of irregular warfare.

Working directly with the Services, the Defense Advanced Research Projects Agency (DARPA), and other DoD components, ONR serves as lead technical agent for the Office of the Secretary of Defense (OSD) Human Social, Cultural, and Behavioral Modeling (HSCB) Program. We are executing the DoD vision for this new domain to provide warfighters and analysts with tools, methods and technologies developed through integration of social and computational sciences. The HSCB program has significantly advanced applied research in this domain, demonstrated operationally focused capabilities with Combatant Command (COCOM) partners, and delivered technology to acquisition Programs of Record that enhance traditional Intelligence, Surveillance, and Reconnaissance (ISR) capabilities by providing insight into the human dynamics of a region.

For example, this year the HSCB Program is delivering a system that provides analytic tools to enhance the analyst's ability to detect trends in events of interest and forecasts to the U.S. Strategic Command (USSTRATCOM) Acquisition Category I (ACAT I) Integrated Strategic Planning and Analysis Network (ISPAN) Program of Record (POR), making this suite of tools available not just to the DoD, but also to interagency and North Atlantic Treaty Organization (NATO) partners as an enterprise solution. Current work in the applied and advanced development pipeline will facilitate the transition of social media sentiment analysis and other open source data to this POR in FY 2013. At the tactical level, HSCB provided USMC Civil Affairs teams participating in the Cobra Gold exercise in Thailand with human dynamics data and analysis to inform the common operating picture, support key leader engagements and humanitarian assistance activities, and provide a baseline for measures of effectiveness.

Our portfolio also emphasizes National Naval Responsibilities (NNR): areas where the other services, the rest of the federal research establishment and the private sector may not have the incentive to investigate – and sole responsibility rests with the Navy. The five NNRs are Ocean Acoustics, Undersea Weapons, Naval Engineering, Undersea Medicine, and Sea Based Aviation. The scope of our research in those areas includes Unmanned Undersea and Aerial Vehicles (UUV/UAV):

One example of research lessons-learned involves the Vertical Take-off and Landing Tactical Unmanned Aerial Vehicle (VTUAV) Airframe. The VTUAV Fire Scout program was initiated

in 2000 as an unmanned system to provide the Navy an intelligence, surveillance, reconnaissance and targeting capability. The Fire Scout airframe was based on a commercial airframe, proposed as a commercial-off-the-shelf (COTS), reliable, powerful, cost-effective solution to the VTAUV requirement. However, deployment in the marine environment led to production refinements in an attempt to address airframe and engine corrosion issues. Based on this experience, we learned that the COTS design of the airframe was not robust enough for daily operating conditions in the harsh marine environment encountered in long-term Navy ship deployments. Like many S&T research investments, we gain knowledge even when we do not succeed in transitioning products to acquisition programs. That hard-earned knowledge earned in failure is precisely what propels us to success in transitioning successful products to acquisition programs down the line. That's why they call it research.

An example of success in the underwater environment is the Mk 18 Mod 1 Swordfish variant of the REMUS 100 UUV, a reliable, deployable, highly portable, multi-vehicle system supporting globally dispersed Underwater Mine Countermeasure capability needs. The Mk 18 Mod 1 Swordfish UUV achieved full operational capability (FOC) in 2008. Follow-on block upgrades will combine two separate UUV programs into the Mk 18 family of systems to deliver improved detection capability against buried mines in high clutter environments and are planned to deliver from FY 2014 through FY 2018.

Unmanned vehicle systems offer many capabilities, including surveillance, reconnaissance, firepower with onboard weapons, and damage assessment. They serve as communications nodes and sensors for signals intelligence, environmental measurements, and identification of nuclear, biological, and chemical threats. Before effective deployment of unmanned vehicles, many technical and operational questions remain to be addressed, such as level of autonomy needed, as well as issues involving reliability, environmental sensitivity, vehicle integration, and operational training. Technical challenges include size, endurance, speed, recoverability, survivability, range and altitude, along with onboard/off-board trade-offs related to communications, intelligence, situational awareness for deconfliction, re-planning capability needed for threat changes, multiple vehicle control, and human interfaces including mixed operations with manned and unmanned aircraft.

Unique to Navy and Marine Corps operations are S&T challenges associated with launch, recovery, and deck operations, especially in proximity to manned aircraft and crew. Damage-tolerance considerations include redundancy in control paths and features to limit propagation of damage, aerodynamic designs allowing continued controlled flight with damage or loss of some airframe elements, and control systems capable of recognizing loss of control surfaces/actuators or changes to aerodynamic configuration of the vehicle and compensating or reconfiguring to allow continued flight. Operations on existing deck configurations with hand signals, visual inspection of data and interfaces, and visual cures for landing and waveoff, pose challenges requiring new technical approaches.

Unmanned Systems will never obviate the need for Sailors and Marines to engage in combat. Our goal is to ensure that they are as safe as they can possibly be in the combat environment. From weaponry to medical care, ONR invests in research about how to better protect personnel. Many of you remember QuikClot, in both the powder and currently utilized Combat Gauze

formulations. Our continuing quest for improved hemostatic products led ONR to support development of an Advanced Trauma Dressing recently approved for external use by the Food and Drug Administration. The Advanced Trauma Dressing is a novel hemostatic bandage with a unique synthetic fibrin carried on a bio-compatible resorbable backing. It was developed to enhance clotting and reduce unwanted adhesion to wounds - while eliminating potential disease transmission found in blood-derived products. Synthetic fibrin dressing is undergoing further development for internal use to stop internal bleeding. The Marines have considerable interest in this product as hemorrhage remains the number one cause of preventable death on the battlefield.

Small Business, Small Business Innovation Research (SBIR), Small Business Technology Transfer (STTR) Programs

ONR small business programs are doing well and can do better. Although we met targets with respect to Small Disadvantaged Businesses, Women-Owned Small Businesses, and Service-Disabled Veteran-Owned Small Businesses, we need to improve our outreach to Historically Underutilized Business Zones and Veteran-Owned Small Business and would like to continue improvements across the board. ONR's FY 2011 achievement of nearly 40% small business awards substantially exceeded the Navy-Marine Corps average, but that is no reason to rest on our laurels.

Our approach continues, for example, to designate all ONR Navy SeaPort(e) support service procurements as 100% small business set-asides, unless it is determined to be in the best interest of the government to proceed with the full and open competitive process. SeaPort(e) is the Navy's electronic platform for acquiring support services in 22 functional areas including engineering, financial management and program management. We emphasized technologies developed by small business in the competitive context of our Navy Rapid Innovation Fund (RIF) Broad Agency Announcement. Finally, we support small business development with ONR's Long Range Acquisition Forecast, a tool being developed on ONR's webpage to assist the small business community in more effectively marketing technologies, goods and services to program components within ONR.

Unique among S&T tools are the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) Programs, which apply a combined 2.8% of externally-executed Navy Research, Development, Test and Engineering (RDT&E) funding to high-priority warfighter needs identified by Fleet/Force acquisition programs. Naval SBIR/STTR focuses on delivering quick, cost-effective, and innovative small business technologies to the Fleet/Force. Small business solutions to Fleet/Force requirements play a key role in Navy's R&D transition strategy, and include development and delivery of technological innovations to the *Virginia*-class submarine's command module, Fire Scout's propulsion system, F-35 airframes, and the Military Sealift Command Dry Cargo/Ammunition Ship (T-AKE) cargo storage system.

SBIR/STTR programs also mine small business potential to address Navy-wide priorities such as energy security, with approximately 25% of annual SBIR/STTR topics addressing alternative energy and energy efficiency requirements across commands. Further, SBIR/STTR programs are a portal for small business entry into Navy's emerging open architecture environment, especially for software requirements of Aegis, Next Generation Jammer, and Joint Tactical

Radio Systems. Positive results of these efforts are seen in the $552 million of Phase III (non-SBIR/STTR) funds Naval program recipients received directly from Naval acquisition program sources in FY 2011. Acquisition investment of additional non-set aside dollars in projects initiated through SBIR/STTR programs to meet their requirements is one of our strongest metrics of success.

Naval SBIR supports delivery of innovative technology, providing incentives to ensure timely engagement by prospective customers and investors. Phase I awards of approximately $150 thousand each (with 570 awards in FY 2011, 25 more than the previous year) include a base-plus-option strategy to ensure business continuity as Proof of Principle is established. Phase II awards of approximately $1 million each to mature project work (with 318 awards in FY 2011, 22 more than the previous year) include a similar funding strategy with technology decision-gates to ensure continuous engagement with acquisition programs to verify "technology pull" from Naval customers. Navy SBIR/STTR supports development and delivery of innovative technology by strengthening small businesses' core competencies through a rigorous 11-month Transition Assistance Program, paired with work with industry prime contractors and integrators to ensure effective partnering on Navy acquisition program requirements. Naval SBIR/STTR participant's dialogue with government and industry culminates in our annual *Navy Opportunity Forum*, where more than a thousand innovators, industry, and government customers learn about small business innovation and explore formal partnership opportunities.

The recent reauthorization of the SBIR/STTR programs includes several changes which should prove beneficial to small business innovation. Among the changes are an increased amount of funds available for technical assistance to small business concerns, increased incentives for prime contractors to utilize SBIR/STTR technologies, and permanent status for a pilot program begun in 2006 to improve commercialization success of Department of Defense projects. These changes along with the many others included in reauthorization should enable Naval SBIR to continue to make a valuable contribution to S&T innovation, Naval RDT&E, acquisition programs, small business development and job creation.

Naval Research Laboratory (NRL)

ONR supports research at the Department of the Navy's corporate lab, the Naval Research Laboratory (NRL). The NRL base program develops S&T to meet needs identified in the Naval S&T Strategic Plan, and sustains world class skills and innovation in our in-house laboratory. The broad-based core scientific research at NRL serves as the foundation that can be focused on any particular area of interest to rapidly develop technology from concept to operation when high-priority, short-term needs arise. NRL has served the Navy, Marine Corps and nation for nearly ninety years with a breadth of the research that facilitates quick assimilation of critical ideas and technologies being developed overseas for exploitation or countermeasures. In addition, NRL remains the lead Navy laboratory for research in space systems, firefighting, tactical electronic warfare, microelectronic devices and artificial intelligence.

Lines of business at NRL include: battlespace environments, electronics and electronic warfare, information systems technology, materials, sensors, space platforms, technology transfer and undersea warfare. For example, NRL research explores Naval environments with wide ranging

investigations that measure parameters of deep oceans, analyze marine atmospheric conditions, monitor solar behavior, and assess survivability of critical Naval space assets. Detection and communication capabilities benefit by research that exploits new portions of the electromagnetic spectrum, extends ranges to outer space, and enables reliable and secure transfer of information. Research in the fields of autonomous systems, bio-molecular science, engineering, firefighting, fuels, lubricants, nanotechnology, shipbuilding materials, sound in the sea, submarine habitability, superconductivity and virtual reality remain steadfast concerns at NRL.

Among our greatest challenges is recapitalizing NRL infrastructure. I invite all of you and your staffs to see this magnificent facility for yourselves, and learn more about the programs, projects, and research undertaken there by some of the greatest scientists and engineers in the world.

ONR Global

The worldwide dimension of S&T is reflected in over 100 percent growth in global S&T investment over the last ten years. When Congress established NRL in 1916 and ONR in 1946, the U.S. was arguably the world leader in S&T. The U.S. monopoly, however, no longer exists, making it imperative to keep our finger on the pulse of S&T in the international environment. Beginning with establishment of our London office in 1946, ONR established offices in Santiago, Prague, Tokyo and Singapore, closely coordinated with the other services and the Assistant Secretary of Defense (Research and Engineering).

The purpose of our effort is to search the globe for emerging scientific research and advanced technologies that enable ONR to address both current Fleet/Force needs, as well as requirements of future Naval missions and capabilities. We work through ONR Global offices to establish new contacts and relationships with international leaders in relevant research fields. This allows us to gain new perspectives and expertise, identify geographically significant trends and advances, and help forecast global trends and threats. It also enables us to recruit the world's best scientists and engineers in partnerships that benefit U.S. forces and allies.

ONR Global programs include the Science Advisor Program which communicates Fleet/Force capability needs to the Naval Research Enterprise (NRE) (consisting primarily of the Navy labs, warfare centers and affiliated universities) and facilitates the development of solutions that can transition back to the Fleet/Force. Program participants are typically senior Navy engineers who coordinate and conduct Naval experimentation, develop prototype solutions, define transition options, and collaborate with Fleet/Force to define S&T investment needs to meet future Naval requirements.

ONR Science Advisors are embedded with the Fleet/Force to ensure that operating requirements are quickly communicated to the Naval S&T community and to facilitate timely delivery of S&T solutions back to the Fleet/Force. They function as the Commanders' link to S&T organizations, assist in prioritizing Command S&T requirements, and help identify transition options. Science Advisor tours are 1-3 years in length, and are highly competitive and sought-after developmental assignments for future NRE civilian leaders, allowing selected scientists and engineers to work directly with operational forces and gain hands-on experience with Command-level engagement, Naval exercises and technology demonstrations both at-sea and in the field.

To increase Naval awareness of global technology, our International Science Program provides scientists from academia, government and industry opportunities to engage leading international scientists and innovators. Our worldwide technical staff helps establish relationships with international leaders in relevant fields, establish direct collaboration between ONR and NRL scientists and their foreign counterparts, and identify significant trends, accomplishments, and centers of excellence for Naval S&T. This strengthens our ability to forecast both trends and threats in global S&T, and avoid technological surprise.

Conclusion

Thank you for the opportunity to discuss Naval S&T. The FY 2013 President's Budget request will enable us to continue moving toward greater integration of capabilities, more effective partnership between research and acquisition, and a clearer vision of how to achieve shared goals among the Army, Air Force, DARPA and other DoD research organizations. At the same time, we also focus considerable energy and investment partnering with performers outside the Naval R&D system in order to tap into the full spectrum of innovative thinking and discovery, and to accelerate transition of appropriate technologies to civilian use.

For these reasons, I believe our S&T investments are sound; represent careful stewardship of taxpayer dollars; and will significantly enhance the safety and performance of our warfighters as they serve in defense of the United States, today and in the future. Thank you for your support.

United States Navy
Biography

Rear Admiral Matthew L. Klunder
Chief of Naval Research
Director, Test Evaluation and Technology Requirements

Rear Adm. Klunder, a native of Alexandria, Va., graduated from the United States Naval Academy in 1982 and earned his wings of gold at Meridian, Miss., in September 1984. Subsequent flying tours were based in Naval Air Station (NAS) Miramar, Calif.; NAS Patuxent River, Md.; Naval Air Facility Atsugi, Japan; and NAS Lemoore, Calif., where he was qualified in numerous aircraft including the E-2C Hawkeye and F/A-18 E/F Super Hornet.

Klunder has served at sea in Airborne Early Warning Squadron (VAW) 112; VAW-115 as a department head, and as commanding officer; and Carrier Air Wing Two as air wing commander. He has made eight deployments and multiple surge operations to the Atlantic, Pacific and Indian oceans and to the Mediterranean Sea and Arabian Gulf.

Klunder's shore tours include serving as a flight instructor, Naval Air Training and Operating Procedures Standardization officer and Commander Naval Air Force, U.S. Pacific Fleet evaluator at VAW-110; test pilot/project officer at Force Warfare Test Directorate; senior operations officer and Single Integrated Operational Plan officer at the Joint Staff J-3/National Military Command Center; Joint Staff liaison officer and Section Chief at the U.S. State Department; Combined Air Operations Center deputy director at Al Udeid Air Base in Qatar; deputy director for Information, Plans, and Security for OPNAV N3/N5; 83rd commandant of Midshipmen at the U.S. Naval Academy; and director of Intelligence, Surveillance and Reconnaissance Capabilities Division, OPNAV N2/N6F2. Highlights during these tours include receiving the 1988 Hawkeye of the Year award, the 1991 Test Pilot of the Year award, and the 2002 George C. Marshall Statesman award.

In November 2011, he became the 24th Chief of Naval Research, with additional duties

as director, Test Evaluation and Technology Requirements.

Klunder received his bachelor's degree from the U.S. Naval Academy and his master's degrees in Aerodynamics and Aviation Systems from the University of Tennessee and Strategic Studies from the National War College.

He has flown more than 45 different aircraft and accumulated 21 world-flying records. His awards include the Legion of Merit (four Awards), Defense Meritorious Service Medal (two Awards), Meritorious Service Medal (two Awards), Joint Commendation Medal (two Awards), Navy and Marine Corps Commendation Medal (four Awards) and various unit and campaign awards.

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DEPARTMENT OF THE AIR FORCE

PRESENTATION TO THE HOUSE ARMED SERVICES COMMITTEE
SUBCOMMITTEE ON EMERGING THREATS AND CAPABILITIES

U.S. HOUSE OF REPRESENTATIVES

29 February, 2012

SUBJECT: Fiscal Year 2013 Air Force Science and Technology

STATEMENT OF: Dr. Steven H. Walker, SES
Deputy Assistant Secretary
(Science, Technology and Engineering)

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INTRODUCTION

Mr. Chairman, Members of the Subcommittee and Staff, I am pleased to have the opportunity to provide testimony on the Fiscal Year 2013 Air Force Science and Technology (S&T) Program.

To protect our nation amidst a myriad of current and future security challenges, the Air Force must be an agile, flexile, ready and technologically-advanced part of the Joint team. The Air Force S&T Program plays a vital role by creating compelling air, space and cyberspace capabilities for precise and reliable global vigilance, reach and power.

Directed by Air Force senior leadership, our S&T Program is based on several enduring tenets. First, we must prepare for an uncertain future and investigate game-changing technologies to affordably transition the art-of-the-possible into military capabilities. To support the Air Force Service Core Functions, we must create technology options across a wide spectrum ranging from institutionalizing irregular warfare capabilities to providing new capabilities to operate effectively in cyberspace and across all domains. We must demonstrate advanced technologies that address affordability by promoting efficiencies, enhancing the effectiveness, readiness, and availability of today's systems, and addressing life cycle costs of future systems. In keeping with our Service heritage, we must continue to foster an appreciation for the value of technology as a force-multiplier throughout the Air Force. We must maintain the requisite expertise to support the acquisition and operational communities and modernize and improve the sustainability of unique research facilities and infrastructure. Finally, we will leverage and remain vigilant over global S&T developments and emerging capabilities to avoid technological surprise and exploit art-of-the-possible technologies for our military advantage.

To accomplish this in a constrained fiscal environment, it is critical that we make the wisest investment decisions possible with the precious taxpayer resources afforded us. We've used this

opportunity as a catalyst to holistically examine our S&T portfolio by considering several fundamental questions guided by our tenets. Where should the Air Force lead the Department of Defense (DoD) from a technology development perspective? Where should we be an integrator of technologies developed by others, and where should we follow the pace of technology being led by our sister Services, other agencies, academia, or Industry?

Recognizing that wise investments are rooted in sound strategies, we embarked more than a year ago on the deliberate and collaborative development of an S&T Strategy, which I introduced to you in my testimony last year. This strategy, which codified our enduring tenets and current overarching priorities, led to the creation of an S&T Plan, published in June 2011. This capstone document describes how the Air Force Research Laboratory (AFRL) implements the Air Force S&T Strategy.

In light of the defense strategic guidance released last month, we ensured our current strategies and plans were appropriately aligned with new and enduring emphasis areas. Our S&T Program supports the Air Force capabilities fundamental to the major priorities of the guidance, such as deterring and defeating aggression, projecting power in anti-access and area denial (A2/AD) environments, operating in the space and cyberspace domains, and maintaining a safe, secure and effective strategic deterrent. Our Air Force S&T Strategy, along with the defense strategic guidance, provided valuable vectors and helped the Air Force make some very challenging investment decisions.

AIR FORCE S&T FISCAL YEAR 2013 PRESIDENT'S BUDGET REQUEST

The Air Force Fiscal Year 2013 President's Budget request for S&T is approximately $2.2 billion, which includes nearly $200 million in support of devolved programs consisting of High Energy Laser efforts and the University Research Initiative. These investments support a robust and balanced foundation of basic research, applied research, and advanced technology development that

will provide demonstrated transition options to support future warfighting capabilities. This year's budget request represents a decrease of $64 million or a 2.8 percent reduction from the Fiscal Year 2012 President's Budget request. This reflects a more modest reduction than that taken across the total Air Force budget and indicates the strong support for Science and Technology from our leadership in this challenging fiscal environment.

Within the S&T portfolio, significant adjustments were made to focus investments in the most promising technologies to develop future warfighting capability. The most dramatic adjustment is an increase of $55 million in our propulsion portfolio in support of new DoD emphasis on A2/AD and energy savings. We were able to maintain stable investments in basic research, directed energy, munitions, and human effectiveness technology areas. Based on our strategy, we reduced our investments in airborne active denial, strategic relay mirrors, and high speed laser communications development in the directed energy portfolio and laser threat warning and small remotely piloted aircraft sensing technologies in the sensors technology portfolio. Finally, we are divesting our investment in deployed airbase technology development and thermal sciences technologies. In these and other technology investment areas, we shifted investment priorities in order to best deliver on our strategic priorities. I will highlight some of these adjustments later in my testimony.

AIR FORCE S&T PROGRAM PRIORITIES

The Air Force S&T Fiscal Year 2013 President's Budget request supports the following overarching priorities that are detailed in our Air Force S&T Strategy document.

Priority 1: Support the Current Fight While Advancing Breakthrough S&T for Tomorrow's Dominant Warfighting Capabilities

Developing technologies to equip our forces of tomorrow is the primary objective of any S&T portfolio. Yet, our dedicated scientists and engineers are equally motivated to contribute to

the current fight by getting their technologies into the hands of our warfighters today. The dollars spent in these near-term investments will undoubtedly pay dividends in the long term. I'd like to share with you a few examples of irregular warfare capabilities that were enabled by our broad S&T investments of the past.

Air Force S&T has played a significant role in developing and delivering combat capability to our warfighters engaged in the United States Central Command (CENTCOM) Area of Responsibility through the deployment of Blue Devil. Blue Devil Block 1 is a persistent intelligence, surveillance, and reconnaissance (ISR) capability demonstrating the first-ever integration of wide area field-of-view and narrow field-of-view high definition day and night sensors cued by advanced signals intelligence sensors. Imagery is transmitted in near-real-time to a Blue Devil ground station or to individual soldiers on the ground. Blue Devil Block 1 satisfies a number of CENTCOM Joint Urgent Operational Needs. Warfighter feedback on the situational awareness provided by Blue Devil Block 1 has been overwhelmingly positive. Since December 2010, Blue Devil ISR has been instrumental in identifying a number of high value individuals and improvised explosive device emplacements. In Fiscal Year 2013, Blue Devil Block 1 will continue to support CENTCOM with four sorties per day.

We also transitioned the Internet Relay Chat Coordinate Extractor, or ICE for short, to the Air Force Distributed Common Ground System program for integration. This capability was created at the request of the Director for ISR Innovations and Unmanned Aircraft System Task Force. ICE is a software application that monitors operational chat rooms for geospatial coordinates and automatically plots those locations on various map programs with greater than 99 percent accuracy. In operation, it has reduced the workload of remotely piloted aircraft operators and improved both Predator and Reaper crew situational awareness and response to time-critical events.

At the request of the 497th ISR Group to address human threat understanding and awareness needs, we demonstrated near-term technologies that provide Air Force Distributed Common Ground System analysts a way to familiarize, understand, and recognize humans from full motion video. This technology provides a solution for the challenging ground target problem. As a result of the demonstration, the customer is working to get the technology transitioned to the Air Force Distributed Common Ground System weapon system.

In response to an urgent operational need for high-resolution three-dimensional data, AFRL partnered with Northrop Grumman, Johns Hopkins University Applied Physics Laboratory, Defense Advanced Research Projects Agency (DARPA), NASA, and the Army Geospatial Center to develop, test, and deploy the High Altitude Lidar Operational Experiment (HALOE) system to the Afghanistan Theater. The Geiger-mode avalanche photodiode focal plane array, developed by AFRL, was the enabling technology that made this system possible. The unprecedented sensitivity, accuracy, and speed of this array allowed in-flight mapping operations at ranges, scan rates, and altitudes several orders of magnitude greater than anything currently fielded today. HALOE is an example of a long-term technology investment for military applications brought to bear to meet irregular warfare needs. This system flew over 550 operational flight hours in 140 sorties while collecting over 55,000 square kilometers of data at an unprecedented 20-centimeter resolution. Working closely with both on-site and geographically separated exploitation teams, HALOE answered over 200 requests for information. Exploited HALOE data has directly supported operations against high value individuals and ongoing combat operations through the characterization of compounds, helicopter landing zones, traffic density and line-of-sight analysis. Following these successes, HALOE has been transitioned to the Army Geospatial Center and was redeployed in 2011 for an additional 12 months.

Priority 2: Execute a Balanced, Integrated S&T Program that is Responsive to Air Force Service Core Functions

Maintaining a balanced, integrated S&T program presents many challenges. As I mentioned earlier, it was necessary for us to take a fresh look at the entire S&T portfolio in light of the defense strategic guidance and re-evaluate our investment in certain areas. It was equally important to determine if there were areas of investment we needed to initiate or increase.

This "clean-slate" approach resulted in decisions to divest of Air Force investment in a number of technology areas, some of which I'll detail here. We moved our space technology portfolio away from "plug and play" satellites while increasing the portfolio in the area of space communications. In the directed energy portfolio, we reduced our investments in airborne active denial, strategic relay mirrors, and high speed laser communications development. In the sensors technology area, we reduced laser threat warning and small UAS sensing technologies. In the air vehicles area we terminated research efforts directed toward micro unmanned air vehicles. Finally, we are divesting our investment in deployed airbase technology development and thermal sciences technologies.

We appreciate Congress appropriating full funding of the Fiscal Year 2012 space S&T lines. However, due to reductions in the Fiscal Year 2013 Air Force budget we had to reduce the overall space S&T portfolio. The space S&T budget was re-aligned with current Air Force Space Command and Space and Missile Systems Center priorities. For example, space-based communication and precision, navigation, and timing technologies were emphasized to improve affordability and reliability. Space situational awareness (SSA) research using ground-based optical systems was increased to provide a better understanding of satellite location, properties, and health, as well as locating potential threats. Most of this research takes place at the Starfire Optical Range and the Maui Space Surveillance System. These sites include the two DoD 3.5-meter class

telescopes that can track fast moving satellites in low earth orbits. Air Force S&T provides significant SSA data to the Joint Space Operations Center in accomplishing its mission to detect, track, and identify all man-made objects in Earth orbit. The most important elements of the Space Superiority portfolio were maintained.

Another area where we made reductions was within our information portfolio, decreasing efforts in command and control and decision-making tools. However, we maintained research efforts in cyber operations, defense, and resiliency consistent with the defense strategic guidance.

One new initiative in this area is the stand-up of an Electronic Warfare Quick Reaction Capability to rapidly assess pilot electronic warfare solutions to warfighters, including the cyber dimension of electronic warfare. This effort will include electronic warfare experiments, modeling and simulation, and both hardware- and software-in-the-loop capabilities to conduct assessments of next generation electronic warfare and integrated air defense system threats.

As we begin the transition to 5th generation aircraft, the Fiscal Year 2013 President's Budget request significantly increases emphasis on applied research to support conventional weapon technologies with the explicit goal of enhancing the capability and capacity of these aircraft, specifically to increase their effectiveness in A2/AD environments. Technologies across the conventional weapon spectrum, including robust munition navigation and control, terminal precision guidance, damage mechanisms, energetic materials, and modeling and simulation, will all contribute to mature selected technologies that enable innovative munition concepts for these aircraft.

We believe speed is important to the success of future Air Force long range precision strike missions for anti-access/area denial environments. To that end, we are exploring the right balance between speed, signature, and electronic warfare to ensure our capability options for the most stressing environments. We are planning to initiate a technology demonstration effort in Fiscal

Year 2013 to demonstrate a high speed capability option. If successful, this High Speed Strike Weapon technology demonstration will be representative of an air-breathing hypersonic missile system with the capability to engage fixed and relocatable targets at extended ranges and survive the most stringent environments presented to us in the next decade. Key technologies to be developed in the first phase of this effort include air-breathing hypersonic engines; advanced materials and structures; guidance, navigation and control for GPS degraded and denied environments; advanced sensors and seekers; and selectable effects warheads. Note that the Department's Conventional Prompt Global Strike program is developing related technologies, but would provide distinctly different capabilities than this effort.

The Supersonic Turbine Engine for Long Range (STELR) demonstration will provide the foundation for a revolutionary increase in capability for cruise missile weapon systems. The purpose of this program is to bring critical key technologies to a readiness level sufficient for transition to a new cruise missile. The planned engine demonstrations, under contract as of December 2011, will take about 34 months to complete in two phases. Phase 1 will be an evaluation of the design and assessment of new and existing hardware to meet the STELR objectives. Phase 2 will consist of two major tests to demonstrate durability, operability, and performance characteristics of the engine technologies, anticipated to be conducted in 2013. The STELR program will allow for technology options for a Long Range Stand-off Missile.

Another initiative is the Identification at Range Integrated Sensor (IRIS), a synthetic aperture Laser Radar (LADAR) program that seeks to provide target identification through geometric imaging at ranges and resolutions exceeding the geometric imaging limits of conventional apertures. The IRIS program builds on the success of the previous Synthetic Aperture LADAR for Tactical Imaging (SALTI) program which the Air Force executed for DARPA. SALTI demonstrated the first Synthetic Aperture LADAR images from an airborne platform but at limited

range. The IRIS will demonstrate Synthetic Aperture LADAR imaging at operational ranges by developing key components, techniques, and algorithms to allow high resolution image formation at long range through degraded atmospheres. The technology promises to provide users the capability of accurately characterizing ground platforms, vehicles, and structures as friendly, noncombatant, or hostile. Additionally, it will identify platform/target type to the extent that high-confidence, real-time application of tactical resources could occur within the rules of engagement. The IRIS architecture is also capable of engaging air targets at extended ranges, making the technology applicable to a variety of combat platforms, including the F-35 Joint Strike Fighter.

We are developing game-changing directed energy technologies for the future warfighter. In the Counter-Electronics High Power Microwave Advanced Missile Project, or CHAMP, Joint Capability Technology Demonstration (JCTD) effort, significant progress has been made in demonstrating airborne electronic attack capability. We have completed two ground effects tests demonstrating high power microwave effectiveness against five classes of electronic targets; performed missile live fire showing the ability to navigate, aim, and trigger inert payload; and successfully integrated the inert system into a B-52 aircraft. We are also reducing the size and weight of high power microwave components while increasing the range for counter-electronics attack.

In the human effectiveness portfolio, we are starting work in aerospace physiology and toxicology to develop physiological and cognitive models to predict operator performance in combined high-gravitational force, high altitude, and stressing environments characteristic of 5th generation air superiority aircraft. This research will also investigate and establish toxicity impacts to the body of advanced fuels, materials, and chemicals used to support existing and future weapon systems.

Starting in Fiscal Year 2013, the Air Force is making additional investments in autonomy initiatives. These include technologies to improve the performance of the human analyst, as well as to provide autonomous control for unmanned platforms in contested environments. This initiative will also develop extended capabilities for groups of cooperating platforms with humans in the loop. We're continuing breakthrough basic research in artificial photosynthesis where our work was recognized on the *Time Magazine* List of Best Inventions for 2011. Researchers we funded at the Massachusetts Institute of Technology developed a device to harness solar energy by splitting water molecules. The researchers produced devices that combine a standard silicon solar cell with a catalyst developed three years ago by Professor Daniel Nocera. When submerged in water and exposed to sunlight, the devices cause bubbles of oxygen to separate out of the water. If a catalyst could produce fully formed hydrogen molecules, the molecules could be used to generate electricity or to make fuel for vehicles. Ultimately, the goal is to produce a low-cost device that could be used where electricity is unavailable or unreliable.

In the area of reducing energy dependency, last year I mentioned the Adaptive Versatile Engine Technology (ADVENT) program which is developing multi-design-point engine technologies that will provide optimized fuel efficiency of up to 25 percent and performance capabilities over a wide range of flight regimes. Building upon the ADVENT program, Fiscal Year 2013 funds will provide for the preliminary design of an adaptive engine technology development (AETD); risk reduction of critical engine components; maturation of an engine core; sub-scale and full-scale ground rig and engine testing; and analysis of uninstalled and installed engine performance. AETD technologies are expected to improve fuel efficiency, durability, and thrust performance for a wide range of air vehicles and applications. Fuel efficiency buys range in combat; therefore, this engine development will also increase un-refueled range for several platforms engaging in A2/AD environments. This preliminary design work and the associated

activities will enable follow-on final design, engineering manufacturing development, and ground and flight test qualification of a production-ready engine early in the next decade for integration into legacy and future aircraft systems. This investment will also help maintain a competitive industrial base in turbine engine technology, an area critical to our future military capability.

Priority 3: Retain and Shape the Critical Competencies Needed to Address the Full Range of S&T Product and Support Capabilities

Ensuring the Air Force continues to have war-winning technology requires careful and proactive management of our Science, Technology, Engineering, and Mathematics (STEM) workforce. We are working alongside the other Services to increase the nation's supply of STEM talent, and to improve our means to attract and recruit future innovators for the Air Force. We must access our nation's best and brightest, and equip them through both the education and training needed for success. In March 2011, the Air Force published *Bright Horizons*, a STEM workforce strategic roadmap that will position the Air Force to ensure we have the right STEM skill sets in place to maintain technological dominance of the air, space, and cyberspace domains. We are identifying current and future STEM workforce requirements, developing strategies to address any workforce gaps, and developing methods to measure for success. We also established an Air Force-level STEM office to coordinate our outreach activities. The Air Force conducts over 150 STEM engagements each year, ranging from scientists and engineers volunteering to judge science fairs to the National Defense Science and Engineering Graduate Program providing scholarships to STEM students. These engagements encourage and leverage local, state, and federal STEM activities, affecting hundreds of thousands of students and teachers across the nation. Our new outreach office will allow us to improve coordination with other Service and agency STEM programs and give us a better understanding of the effectiveness and impact of our STEM investments.

Priority 4: Ensure the Air Force S&T Program Addresses the Highest Priority Capability Needs of the Air Force

Our process for creating and executing Air Force Flagship Capability Concepts (FCCs) is maturing well. Last year I told you about these newly established Air Force-level integrated technology demonstration efforts. Key factors in commissioning an FCC include having a well-defined scope and specific objectives desired by a Major Command (MAJCOM). The technologies are matured by AFRL with the intent to transition to the acquisition community for eventual deployment to an end user. These FCCs are sponsored by the using command and are vetted through the S&T Governance Structure and Air Force Requirements Oversight Council to ensure they align with Air Force strategic priorities.

The High Velocity Penetrating Weapon FCC was established to demonstrate critical technologies to reduce the technical risk for a new generation of penetrating weapons to defeat difficult, hard targets. The ultimate goal is to demonstrate 5,000-pound-class weapon penetration capability in a 2,000-pound-class weapon. Since last year we successfully completed the first ground-based test to assess the survivability of the warhead design. Data from this test and planned tests in the future will continue to reduce critical technology risks and inform Air Combat Command and the Air Armament Center as they progress toward a Materiel Development Decision for a proposed Hard Target Munition acquisition program.

The Air Force decommissioned the Responsive Reusable Boost for Space Access FCC during our annual review of its progress. Due to current fiscal realities, Air Force Space Command was no longer able to commit to the transition of these technologies according to the planned timeline. AFRL continues to explore advanced structures and subsystems technologies and is working toward a reusable hydrocarbon-fueled engine technology demonstrator.

We commissioned a new FCC for Precision Airdrop in response to a request from the Commander of Air Mobility Command for technologies to improve airdrop accuracy and effectiveness while minimizing risk to our aircrews. AFRL, the Aeronautical Systems Center, and Air Mobility Command members established a working group to explore all aspects of the airdrop missions from re-supplying our warfighters in the field to providing humanitarian aid to people in need across the globe. This team, with valuable support and participation from the Army, spent several months investigating the myriad of challenges associated with each of the different types of airdrop missions. They identified multiple technologies which may reduce the error associated with airdrops and put forward the most promising set. Technologies that will be developed for potential transition include a forced exit delivery system, bundle tracking, more precise methods of wind sensing, and a humanitarian airdrop delivery system that will deliver aid without putting local populations at risk.

The Selective Cyber Operations Technology Integration (SCOTI) FCC is executing smoothly toward providing cyber technologies capable of affecting multiple nodes for the purposes of achieving a military objective. The standardized delivery platform being developed is scheduled to be complete in Fiscal Year 2013 and will serve as a baseline for current and future integrated cyber tools.

To ensure these FCCs and other advanced technology development efforts are postured for successful transitions to warfighting capability, the Air Force is continuing deliberate efforts to better align S&T planning, technology transition planning, and development planning. The linkages between these planning activities are critical to initiating acquisition programs with more mature technologies and credible cost estimates, and we are mandating this linkage in new Air Force policy.

The Air Force S&T planning process is driven by S&T needs identification and S&T solutions formulation in response to documented capability needs provided by the MAJCOMs. Capability Collaboration Teams conduct systems engineering decompositions to determine if S&T is required to address Product Center technology needs in support of the documented MAJCOM capability needs. These teams include subject matter expert representatives from the MAJCOM, appropriate Product Center, and AFRL. The output is a set of vetted MAJCOM prioritized S&T needs based upon critical technologies required for ongoing or prospective materiel solutions supporting documented MAJCOM capability needs. Following S&T needs identification, the teams identify and vet potential S&T solutions mapped to MAJCOM capability needs by mission area. Recommended S&T solutions become internally managed AFRL S&T projects, or are proposed as candidate Advanced Technology Demonstrations (ATDs), FCCs, or JCTDs that require approval by their respective governing bodies. Integrated Product Teams are established for transition planning. Additionally, AFRL is conducting early systems engineering activities in all major technology demonstration efforts, and documenting aspects of these activities in baseline documents. AFRL has established a Chief Engineer position in the Headquarters and in each of the Technical Directorates to lead these activities.

Air Force S&T activities must support, and are informed by, development planning efforts. S&T communities identify technology maturity as well as opportunities (e.g., the "art of the possible") to inform the formulation and consideration of candidate concepts. Development planning communities identify technology needs and technical risk areas of candidate concepts to inform S&T planning. Finally, the Air Force conducts the necessary development planning activities to transition ATDs, FCCs, and Air Force-led JCTDs into acquisition programs.

Another way we address the highest priority capability needs is by recognizing that industry is a critical partner in advancing technologies and delivering war-winning capabilities. To better

inform and leverage the work of our industry partners, we have developed a new process to collaborate on Industry Independent Research and Development (IR&D) projects. We completed our first review using this process toward the end of 2011. Senior Air Force leadership was pleased with the products and processes and requested a second IR&D review which we are currently conducting. These reviews have dramatically increased Air Force insight into industry IR&D portfolios, leading our researchers to establish contacts with the reviewed companies and consider collaboration opportunities. Equally important, our first review led industry researchers to request follow-up meetings with the Air Force to ensure their portfolio is aligned with our needs. We believe this new process will help advance the "state-of-the-art" in the technologies of greatest need to the Air Force while helping industry make smart in-house research investment decisions. The end result is maximizing return on investment for both the government and industry.

I would also like to provide some feedback on how the Air Force is engaging with small business to execute the Rapid Innovation Fund (RIF). The Air Force received 730 white papers in response to the RIF broad agency announcement, 88 percent of which were submitted by small businesses. We assembled a team of over 85 evaluators from across the Air Force. One hundred thirteen white papers valued at $253 million were scored in the top category, defined as a small business meeting a critical need with a clear transition path to a major acquisition program.

The Air Force asked submitters to focus on key technology areas in their white papers. These included support to current contingency operations, particularly in the areas of precision air delivery, low-metal or non-metallic detection devices, persistent wide-area airborne surveillance and exploitation capability, combat search and rescue, and man-portable fire suppressant. We also asked for ideas in cyberspace superiority and mission assurance, improved system sustainment, and power generation and energy for platforms.

In addition to the technical approach and cost, a primary consideration in our evaluation of white papers was transition potential. We also considered the degree to which the technical approach was relevant to our need, whether it enhances or accelerates the development of an Air Force capability, and if it reduces development costs of acquisition programs or sustainment costs of fielded systems. We approved 20 white papers and have invited those vendors to submit a proposal in competition for the $24 million. We anticipate making approximately 12 awards for this initial phase of the RIF program.

CONCLUSION

This budget request reflects our re-focused S&T portfolio given budgetary challenges and the new defense strategic guidance. I believe this request also reflects the promise of future warfighting capability enabled by the technologies that will be developed with this investment. We recognize that these challenges will not disappear tomorrow, and that is why we've improved our processes to make better investment decisions and to capitalize on these investments to efficiently deliver capability to our warfighters. We're institutionalizing these initiatives in our policies and procedures across the Air Force. The S&T portfolio we present to you today, after all, is the genesis of our warfighting capability of tomorrow. Our Airmen and our nation are depending on it!

Mr. Chairman, thank you again for the opportunity to testify today and thank you for your continuing support of the Air Force S&T Program.

BIOGRAPHY

UNITED STATES AIR FORCE

DR. STEVEN H. WALKER

Dr. Steven H. Walker, a member of the Senior Executive Service, is Deputy Assistant Secretary of the Air Force for Science, Technology and Engineering, Office of the Assistant Secretary of the Air Force for Acquisition, Washington, D.C. Dr. Walker is responsible for preparing policy, guidance, and advocacy for the Air Force's annual $2 billion science and technology program. He provides annual testimony to Congress, technical advice and counsel to the Air Force Acquisition Executive, and the Air Force's science and technology recommendations to the Office of the Secretary of Defense. In addition, Dr. Walker is responsible for overseeing a broad range of engineering and technical management policy spanning systems engineering; environmental safety and occupational health; industrial preparedness; and functional management of more than 14,000 military and civilian scientists and engineers.

Dr. Walker has more than 20 years experience in civil service. He began his engineering career in the Air Force Research Laboratory's Air Vehicles Directorate in Dayton, Ohio, providing expertise in airplane exhaust system fluidics and aero-acoustic modeling and simulation research. Subsequent assignments include Program Manager of the Unsteady Aerodynamics and Hypersonics Research Program at the AFRL's Air Force Office of Scientific Research in Arlington, Va., and special assistant to the Director, Defense Research and Engineering at the Pentagon. Dr. Walker has also served in the Tactical Technology Office at the Defense Advanced Research Projects Agency. As a Program Manager in the TTO, he initiated the $500 million DARPA/Air Force Falcon program to develop and flight test technologies for long duration hypersonic flight and affordable, responsive space lift. Prior to his current assignment, he was the TTO Deputy Director.

Dr. Walker is an Associate Fellow of the American Institute of Aeronautics and Astronautics where he has served on the AIAA Air-Breathing Propulsion, Aero-acoustics and Fluid Dynamics Technical Committees. He has written numerous technical publications based on his research and experience.

EDUCATION

1987 Bachelor of Science degree in aerospace engineering, University of Notre Dame
1991 Master of Science degree in mechanical engineering, University of Dayton
1997 Doctor of Philosophy degree in aerospace engineering, University of Notre Dame

CAREER CHRONOLOGY

1.1987 - 1997, research and development engineer, Air Vehicles Directorate, Air Force Research Laboratory, Dayton, Ohio
2. 1997 - 2001, Program Manager, Air Force Office of Scientific Research, Arlington, Va.
3. 2001 - 2002, special assistant to the Director, Defense Research and Engineering, the Pentagon, Washington, D. C.
4. 2002 - 2006, Program Manager, Tactical Technology Office, Defense Advanced Research Projects Agency, Arlington, Va.
5. 2006 - 2010, Deputy Director, Tactical Technology Office, Defense Advanced Research Projects Agency, Arlington, Va.
6. 2010 - present, Deputy Assistant Secretary of the Air Force for Science, Technology and Engineering, Office of the Assistant Secretary of the Air Force for Acquisition, the Pentagon, Washington, D.C.

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Statement by

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Subcommittee on Emerging Threats and Capabilities
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At DARPA, we are often asked to predict the future.

After all, since it was created in 1958, DARPA's singular mission has been to create and prevent strategic surprise. Simple. Clear. Direct.

It may appear that the best way to create strategic surprise is to predict what's next. Predict with great accuracy and as far as out as possible. We hunger to know what's next. To predict the future. But our hunger to predict is not matched by our ability to do so.

In 1964, Arthur C. Clarke, science fiction writer, inventor and futurist observed:

> "Trying to predict the future is a discouraging and hazardous occupation, because the prophet invariably falls between two chairs. If his predictions sound at all reasonable, you can be quite sure that in 20, or at most 50 years, the progress of science and technology has made him seem ridiculously conservative. On the other hand, if by some miracle, a prophet could describe the future exactly as it was going to take place, his predictions would sound so absurd, so far-fetched, that everybody would laugh him to scorn."

At DARPA, we believe it is not about predicting the future... it is about building it. Indeed, the technical visionaries at DARPA are not oracles—they are builders.

Chairman Thornberry, Ranking Member Langevin, Members of the Subcommittee, my name is Ken Gabriel. I am the Deputy Director of the Defense Advanced Research Projects Agency. I would like to highlight some of the accomplishments of the Agency over the last 12 months and, outline the challenges we see and our intentions for the coming year. The impact from some of our work will be felt years from now. Other work is contributing sooner and is in the fight today. Regardless of where in that spectrum we are, DARPA's work is underscored by a focus on building. Building capabilities and demonstrations at convincing scale that drive the advance of the underlying technologies and science. We innovate by building. We achieve our best, by building.

Building the future.

Some of the Agency's greatest contributions— things we now take for granted and as having been inevitable were, at their inception, often considered impossible. The Internet, stealth, UAVs for example, when first proposed were described by some as impractical, far-fetched, and risky.

But these seemingly impossible things were turned to the improbable and then to the inevitable by people with vision and determination to make their vision real. A determination to build. DARPA program managers have a hunger to succeed, a sense of urgency, and a commitment to the Nation's Security. For more than 50 years, the Agency has sought the Nation's best, given them the resources they need, and cleared the obstacles in their way.

The lifeblood of DARPA is the cadre of program managers and leadership executives that represent some of the best technical minds in the country. Professionals who put their careers in suspended animation in service to country. Accountable to the Agency, to the Department, and to our Warfighters, DARPA's program managers are drawn from academia, industry, non-profits, the Services, and laboratories and serve for a tour of 3 to 5 years. Program managers, office directors, the Director, and the Deputy Director; all change on a regular cadence. This practice results in roughly 25 percent annual starts and exits and ensures the Agency is current with existing and emerging technological trends, encourages a continual challenging of conventional approaches, and imparts an ethic of urgency.

One key continuing challenge for the Agency and, by extension, for the well-being of the Department of Defense is recruiting this talent to service. DARPA's ability to do so demands rapid, agile and efficient hiring. In the last 2.5 years the Agency has recruited more than 75 new program managers – this has been essential to many of our efforts including DARPA's significantly expanded cyber program and our big data efforts in support of operations in Afghanistan, among others. DARPA has demonstrated successful and responsible use of its hiring authorities. Indeed, the Agency has been at essentially present-day personnel levels since 1992 and has never exceeded the allocated top-line number of authorized full-time equivalents. Timelines for hiring within the Agency are short and match the cadence and tempo of tours reflected above. Simply put, we cannot undertake a 6-month or even a year-long hiring activity, as is common in government, for a technical subject matter expert critically needed to undertake efforts in response to a technological shift and with other competing career opportunities. Rather, we need to sustain an efficient and expedient engagement that is naturally always within the construct of fiscal, ethical, and legal responsibilities. This is not something we can afford to risk. Together we must protect it vigorously.

Our business practices are a vital part of building.

Execution is what allows the people at DARPA to build. To turn ideas into reality, the Agency must operate effectively with agility, speed, and technical and administrative integrity. DARPA executes a budget of nearly $3 billion as appropriated by Congress. It does so with approximately 120 program managers and a roughly equal number of Government support staff. Financial resources and lean business practices allow the Agency to pursue ideas that most dare not touch. And to do so quickly. There are no entitlements to programs or people, no captive laboratories, no immutable tenets. The Agency applies a "thoughtful ruthlessness" in its dogged pursuit of the best people, ideas, and output.

The breadth, urgency, and technical demands of DARPA programs are real. The innovative ideas the Agency pursues are fragile and fleeting, and the organization's business practices must be aligned with the speed and flexibility required to pursue those ideas. The authenticity of Defense applications demands an organization dedicated to excellence in execution through all levels of management, policies, and personnel. Indeed, in the face of such pressures, creativity requires heroic intellectual leaps not just from the technical side of the organization, but equally from the support side of the organization. DARPA has support offices dedicated to essential functions that enable the mission through innovative practices that mirror the technical innovations of the Agency.

In past years, Congressional oversight committees expressed concern that DARPA's financial execution was inadequate; specifically, that DARPA was not obligating a significant fraction of the money it had requested. These concerns resulted in budget cuts and rescissions, but, as well, obligation delays meant fewer resources at work for the Department. In our 2010 written testimony, we reported on the steps the Agency had taken to improve business process and the resulting, significant improvements in financial execution.

In 2011, we maintained our emphasis on responsible and efficient financial execution. At the end of September 2011, the Agency's obligation rate was 21 points higher (85 percent) than the 5-year average (64 percent) despite the delayed 2011 Appropriations signing. At the end of fiscal year 2011, the improved execution translated into more than $600 million in the performer community, working for the Department and Nation. Speed is part of the vibrancy of innovation and building. Better business practices are just better Government. It affects not only the performers, but the Agency too.

People come to DARPA not for careers in Government, but to serve. Over the decades, this cadre has consistently delivered. The list of historical achievements is well known, long, and includes stealth, the Internet, and UAVs. Today we are working on the production of vaccines from tobacco plants measured in days rather than months; prosthetics controlled directly by thoughts; and clean-slate, convergent approaches to defensive and offensive cyber security capabilities among many other innovations.

Discouraging the fear of failure.

Doing things that have never been done before, building the future, comes with risk. Risk of failure. As a Department, as a Nation, we must not forget that great accomplishments often had failure along the path. We cannot fear it.

The history of the Corona program and imaging satellites tells us that it took 13 launches over several years before the first images were collected. Thirteen. Each of the other 12 launches failed to collect a single image. No doubt, some at the time called them failures. But each of those 12 launches informed the next build and successively created the capability of imaging satellites from what seemed impossible, to just improbable and, eventually, inevitable. The first successful flight in 1960 covered 1.65 million square miles of Soviet territory—more than all earlier U-2 missions combined.

A more recent example is HTV-2, a DARPA program that is part of the Department's prompt global strike activities. HTV-2 seeks to travel at Mach 20 in an unmanned, boost-glide, maneuvering vehicle. The fastest high lift-to-drag ratio aircraft ever built. Mach 20. Twenty times the speed of sound. That means anywhere in the world in 60 minutes or less. Or New York to Los Angeles in 11 minutes and 20 seconds, with the surface of the vehicle at blast furnace temperatures: 3500 degrees F—the temperature of molten steel. We are essentially burning the airfoil as we fly it. It might seem impossible. It's not. It's just hard.

There have been two test flights to date. The first revealed an underestimation and simulation of aerodynamic effects in one of four variables needed for controlled hypersonic flight. The second

flight demonstrated that we had fixed the aerodynamic control from the first flight, but precisely because we reached a different stage of the flight, we had 3 minutes of fully aerodynamically controlled flight at Mach 20. Although neither of the flights completed all elements of the tests, the two flights combined fielded the largest collection of flight-test assets assembled and yielded more aerodynamic and test measurement data at these hypersonic regimes than what has been collected in ground tests over the last 40 years. There's no way to learn to fly at Mach 20 unless you build... and fly.

From hypersonic flight to detecting overpressure during blasts, building remains important. A persistent, acute DoD need has been for a reliable, accurate and affordable method to detect and characterize traumatic brain injury or (TBI). We undertook basic and fundamental work in neuroscience and the effect of blasts on the fine structure that revealed the role of over pressure in TBI. Overpressure waves distinguish blast exposure from other types of causes of TBI (for example, sports injuries where acceleration and kinetic impact, but no overpressures are contributors).

Informed by this neuroscience work, DARPA launched a program to build, demonstrate, and evaluate a blast gauge that incorporated a pressure sensor, acceleration sensor, and recording electronics. Four versions of the gauge were built over the course of a year and for a total development cost of approximately $1 million. Each version building in the learnings—learnings from both the use and manufacturing of the earlier versions.

In partnership with the Army, the final version was fielded to an entire brigade of 841 warfighters, the 2nd Brigade, 4th Infantry Division in RC South over the course of six months—from August 2011 to February 2012. The initial units used to outfit the first brigade cost $85 per unit, 3 per warfighter per month of deployment for a total cost of $1.6M. But over time, informed by the building and shipping of over 16,000 units and incorporating improved manufacturing processes, the cost is now approximately $45 per unit, and the next brigade will be outfitted for $540,000.

At DARPA we plan for success, not failure. We don't seek, embrace, or celebrate failure. We learn from our failure, and we build future capabilities through persistence, focus, and informed trial. We don't encourage failure; we discourage the *fear* of failure.

The price of not building.

In the best of times, failure is difficult to endure. There is a hunger and need to be efficient. To husband our resources. In times of fiscal pressure that hunger is sharper.

The conventional wisdom and response for relief is to roadmap, coordinate and plan to better predict and better prepare. To slow our efforts so as to retire more risks, to build less often and thus lower costs. If we can improve our predictions, we can better plan for and build the systems needed.

The argument being, "We can't afford to fail." The trouble with this approach is that, out of balance, it fails to weigh the risks of not building. Because it is equally important not to lose

sight of the companion worry: "What's the price of not building often and along shorter timelines?"

At DARPA we examined this fundamental argument through the lens of two parameters: per-system cost and total number of systems to be purchased. Across many different types of representative defense systems— air, land, and sea— over the last 2 to 3 decades, the analysis reveals a consistent and disturbing pattern.

Programs of record begin with a target per-system cost and total number of systems to be purchased. Over the course of a program, due to a variety of factors including financial constraints, technical risks and changing priorities, there is a steady *increase* in the per-system cost and a corresponding *decrease* in the total number of systems to be purchased.

For the systems we analyzed, with associated development and fielding times ranging from 14 to 30 years, the final number of systems purchased were typically *one-fourth* the original number of systems envisioned at the start of the programs.

The judgment of whether fielding one-fourth of the original number of systems is enough is not DARPA's. This pattern of increasing timelines to initial operational capability, increasing cost per unit delivered, and companion decrease in the number of units, is divergent with an increasingly dynamic threat environment. Our next step was to attempt to reveal what is causing the divergence.

Many people are familiar with Norm Augustine's chart that shows the extrapolated cost of a fighter aircraft intersecting with the Defense budget, such that sometime in 2054 the entire Defense budget will be required to buy one aircraft.

Further, given the pace of global technological development and access, we can no longer afford the *time* it takes us to build Defense systems. In DARPA's 2010 and 2011 written testimony, we highlighted and described the Agency's advanced manufacturing initiative, with the focus on reducing and controlling for time. But it is not simply the argument that time is money. As a Department, we are at a juncture where not only the increasing cost but the increasing time it takes us to develop defense systems is a vulnerability in and of itself.

In the past, defense technology could be relied on to be ahead of civil or commercial technology. Defense technology drove commercial technology and the defense industry was often an early adopter and customer of new technologies. And in a few unique areas, defense will remain ahead of commercial capabilities. But the number of these areas is decreasing.

In the last 2 decades, this long-standing precedent has begun to reverse, and commercial technology has begun to outstrip defense technology. This is perhaps felt most acutely in cybersecurity and the consumer electronics products and services that have fundamentally changed the way we connect and interact with the world and each other.

Vulnerabilities created by commercial technologies.

Unintentionally, and without malice, commercial consumer electronics has created vulnerabilities by enabling sensors, computing, imaging, and communications capabilities that as recently as 15 years ago, were the exclusive domain of military systems. These capabilities now are in the hands of hundreds of millions of people around the world and in use every day.

The effect of these commercial capabilities on Defense and National Security may be seen in the impact of these trends on electronic warfare (EW) systems and anti-access and area denial (A2AD). EW: an area of historic advantage to the US military; and A2AD: an area of increasing concern in several strategic regions of the globe.

This is not an abstract vulnerability. We have not enjoyed spectrum dominance since about 1997. Up until then, our EW systems could both detect and respond effectively to EW threats directed at us. In the last 15 or so years, however, that has ceased to be true. In both waveform complexity and carrier frequency, adversaries have moved to operating regimes currently beyond the capabilities of our systems.

What we find are three principal reasons why it has been possible to apply commercially available electronic capabilities to produce military-grade EW systems.

First, as microelectronic devices continue to shrink in size, they are, perhaps counter intuitively, also improving in performance. For example, smaller microelectronic devices are able to switch faster and, thus, operate at higher frequencies. This means that specialized microelectronic devices produced for DoD are now matched or nearly matched in performance to standard silicon-based microelectronics commercially available from multiple, global sources.

Second, custom signal processing chips that took 2 to 3 years to develop and required chip designers, sophisticated design, and simulation tools along with chip fabrication facilities are increasingly being replaced by programmable chips or field-programmable gate arrays (FPGAs). Unlike custom signal processing chips that have their specific function fixed at the time of fabrication, FPGAs can be programmed, and reprogrammed, like software, *after* fabrication. This means that developers can cut as much as 18 months off development schedules, from 3 to 4 years to as little as 1.5 years.

Finally, the demand created by the global, mobile communications industry has led to a global manufacturing capacity and economic efficiencies that deliver the above capabilities at ever decreasing prices.

EW was once the province of a few peer-adversaries. It is now possible to purchase commercial off-the-shelf (COTS) components for more than 90 percent of the electronics needed in an EW system. This has reduced the barriers to developing, producing, and fielding such systems to within the capabilities of many nation states and non-state actors.

And because of the improved performance of commercially available, programmable microelectronics, nearly a dozen countries are now producing EW system variants and new versions at a much faster cadence than we have; from a pace of a new system every 5 to 10 years 2 decades ago, to one every 1.5 years today. This means that our conventional approaches no

longer afford us a time or capability advantage. Increasingly, our conventional approaches are divergent with the threat.

These insights led us to new investments that leverage COTS technology where it makes sense to, counter COTS where we need to, and transcend COTS where practical.

Leveraging COTS.

If a commercial computer chip is fast enough to accomplish a task in a US military system, there is no point to designing an alternative; just use what is available. This does not imply equivalent capability at the system level. Namely, we are not doomed to an even playing field just because we are using the same processor chip as an adversary. We can make a network of such chips to overcome the adversary's system. Better algorithms tightly integrated with the hardware, and improved cooling to wring more performance from each chip, are two examples where technological advances would allow us to prevail even when we are all using the same basic technology.

Countering COTS; alternatives to GPS as an example.

We use global positioning system (GPS) because it is cheap and easy. It is COTS for us – most of our precision-guided munitions capability, as well as timing for our command and control systems, have become dependent on GPS. The adversary knows this and has aggressively sought means to counter our dependency on GPS. Jammers and commercially driven spectrum compression may threaten our ability to use GPS in areas denied. Attempts to make GPS receivers that can survive that jamming is impractical and not convergent with the threat. GPS signals are inherently weak. The ease with which GPS signals are jammed or spoofed motivate developments of development of alternative position, navigation, and timing approaches that are not dependent on GPS alone.

An example of how we might counter COTS is to recognize that GPS is just one way of providing positioning, navigation, and timing data. But it is not the only way. We might carry our own navigation system. The same trends in COTS advances, used to build alternative navigation guidance systems such as highly integrated, inexpensive, low power accelerometers and gyros, may enable the DoD to accomplish its mission even when GPS is denied. Our analysis revealed that extending the performance of today's inertial guidance systems by a factor of 20—from roughly 1 minute to 18 minutes, will permit 98 percent of our GPS-dependent weapons to operate at GPS accuracy during their mission duration without a GPS signal.

Transcending COTS.

COTS electronics is a formidable source of new, high performance technology, but it has inherent limitations. The main one is economics– industry is motivated by the profit incentive, and modern electronics is extremely expensive to design and produce in small volumes. This highly nonlinear effect of high volume manufacturing is why the extremely complex technology inside cell phones appears to be so cheap.

This opens a window of opportunity for the US military anywhere that product unit volumes will be low, COTS electronics will be unavailable. Very high power transmit/receive modules for radars and radios, for example, are simply unnecessary in the COTS space, so the Military must design and produce its own. Although this performance advantage will come with a cost greater than commercial products, this means the United States will enjoy a technical lead over any potential adversary who cannot invest and do likewise.

Operational vice intelligence capabilities in cybersecurity.

In cybersecurity, we have the area that most highlights the danger of taking too long to build. The shelflife of cybersecurity systems and capabilities is sometimes measured in days. Thus, to a greater degree than in other areas of defense, cybersecurity solutions require that we develop the ability to build quickly, at scale, and over a broad range of capabilities. This is true for both offensive and defensive capabilities.

DARPA's role in the creation of the Internet means we were party to the intense opportunities it created and share in the intense responsibility of protecting it. We should emphasize that national policymakers, not DARPA, will determine how cyber capabilities will be employed to protect and defend National Security interests. But the Agency has a special responsibility to explore the outer boundaries of such capabilities that the United States is well prepared for future challenges.

To date, there has been much focus on increasing our defensive capabilities. To be sure, the list of needed capabilities is long. Our networks may be safer than they were, but systems are often easily penetrated, accounts are routinely hacked, intellectual property and sensitive information are compromised, and the supply chain is not secure. And because computers are embedded in nearly all our systems—cyber attack cannot be regarded as a threat only to our networks and information—but rather to all our physical systems as well.

Protecting cyberspace and the Nation requires both significantly enhanced defensive and offensive cyber capabilities; capabilities across the full spectrum of the conflict. Of note, our Intelligence Community has significant cyber capabilities, but the are geared predominantly to intelligence tasks. The tasks required for Defense purposes are sufficiently different that we cannot simply scale our intelligence cyber capabilities and adequately serve the needs of the Department of Defense. Rather we need cyber options that can be executed at the speed, scale, and pace of our military kinetic options with comparable predicted outcomes.

Modern warfare demands the effective use of cyber, kinetic, and combined cyber and kinetic means. That will happen only if cyber capabilities are at scales and speeds matched to our kinetic options.

Informed by these insights and with a willingness to accept our responsibility to contribute, we assessed that DARPA has a significant role to play. We recruited an expert cyber team of individuals from diverse experiences including the "white hat" hacker community, academia, labs and nonprofits, major commercial companies, in addition to the Defense and Intelligence Communities.

We launched several programs, increased the level of activities in others, and closed some out. Our cyber efforts are designed to create the capabilities needed for military missions. We need more options. We need more speed and scale. We need approaches that match the diversity, dynamic range, and operational tempo of DoD activities. This cannot be achieved by simply doing more of what we've been doing or by increasing our intelligence-oriented cyber capabilities.

Examples include programs such as Clean-Slate design of Resilient, Adaptive, Secure Hosts or CRASH, which takes its inspiration from the defensive mechanisms of biological systems and seeks to develop cybersecurity technologies by radically rethinking basic hardware and systems designs. And PROgramming Computation on EncryptEd DATA or PROCEED, which is a big reach program motivated by recent breakthroughs in what is called fully homomorphic encryption, which could fundamentally change the nature of assured computations on untrusted hardware. If successful, PROCEED puts cybersecurity into an encryption realm, a realm that requires state-level computational resources.

The Cyber Fast Track program recognizes an untapped pool of experts and innovators who could contribute, if we provide a path. That path matches both their execution and the shelflife of cybersecurity products. In the last 7 months, more than 100 proposals were received by Cyber Fast Track, and 32 awards were made. Just as important, the average time from receipt of proposal to award is 7 days. We note that the process and contracting mechanism rigorously meets DoD regulations for competition and awards; we need not be slow to be fair, ethical, or prudent. Eighty-four percent of these small companies and performers have never done business with the Government before, expanding the number and diversity of talent contributing to the Nation's cybersecurity.

Since 2009, DARPA has steadily increased its cyber research. Our cyber research funding is increasing from $228 million in FY2012 to $246 million in FY2013. And over the next five years, our proposed investment in cyber research will grow steadily from 8 percent to 12 percent of topline.

We are also shifting our investments to activities that promise more convergence with the threat that recognize the unique needs of the Department of Defense. To this end, in the coming years, DARPA will focus an increasing portion of our cyber research on the investigation of offensive capabilities to address military-specific needs.

We began these efforts on our own. But part of the growth in our resource commitment beginning in 2012 and extending through 2017, is at the hand of senior leaders in the Department, who added $500 million over 5 years for clean-slate, convergent cyber research at DARPA.

DARPA's engagement in cyber is not new. This expanded effort builds on an existing foundation and continuing contributions to cyber. Indeed, past DARPA-developed technologies are widely prevalent in military, intelligence, and commercial use today. But there is still much to do.

DARPA activities are part of a larger whole within National Security at the National Security Agency , the newly formed CYBERCOMMAND, the Services, the private sector, universities, nonprofits and, as appropriate, the Department of Homeland Security.

Clearly, the challenges of cyberspace require the concerted efforts of many. Indeed, we all must be protectors of and operate within cyberspace.

And these challenges also demand the involvement of technical experts at unprecedented levels. We expect that part of our responsibility will be in advisory roles during the formation of policy and legal frameworks, because new policies and laws—domestic and international—must be executable, enforceable, and sustainable.

To be of use, such policies and laws will demand evaluation and adjustment on timescales that correspond to the dynamic nature and compressed evolutionary timescales of advances in cyberspace. We'll have to move faster than we are accustomed to. We'll need the tools and guidance to do so.

Discomfort and strategic surprise.

Some of these observations feel uncomfortable. Even to us. Our responsibility, however, is to the uncomfortable. It is the Agency's singular mission to identify divergences and the threats and opportunities they represent. These are the seeds of strategic surprise.

We need approaches that are convergent with the challenges and deliver systems and solutions on timescales and with agilities that match operational needs.

In this time of fiscal constraint, we are committed to doing our part. But this does not mean that we lose our nerve for building.

Thank you.

Dr. Kaigham J. Gabriel
Deputy Director
Defense Advanced Research Projects Agency

Dr. Kaigham (Ken) J. Gabriel most recently was the Founder, Chairman and Chief Technical Officer of Akustica, a semiconductor company commercializing Micro Electro Mechanical Systems (MEMS) sensors for consumer electronics products. Akustica, based in the United States with a global supply chain and customer base, pioneered the use of digital silicon microphones and shipped more than 5 million units to the PC/notebook industry. Since founding the company in late 2001, his responsibilities focused on managing continued technology innovation, product development, manufacturing, and business execution.

In 2003, Dr. Gabriel was named a Technology Pioneer by the World Economic Forum at Davos, one of 40 selected worldwide. He is the co-founding Executive Director of the MEMS Industry Group, the principal trade organization representing the MEMS industry globally. Ken is widely regarded as the architect of the MEMS industry.

From 1992 to 1997, Dr. Gabriel was at the Defense Advanced Research Projects Agency. In 1992, he was recruited to start the Agency's MEMS program and grew the effort to more than $80 million a year with 70+ projects. He was promoted to Director of the Electronics Technology Office (1996-1997), where he was responsible for nearly $450 million annually in electronics technology programs including advanced lithography, electronics packaging, MEMS, optoelectronics, millimeter and microwave integrated circuits, and high-definition displays.

Dr. Gabriel counts among his honors the Carlton Tucker Prize for Excellence in Teaching from the Massachusetts Institute of Technology; appointment to the Senior Executive Service; co-chair of the Task Force on Defense Technology Strategy and Management for the Defense Science Board 1999 Summer Study on "21st Century Defense Technology Strategies"; and two technology briefings to the Secretary of Defense.

Prior to his Government service, Dr. Gabriel was at AT&T Bell Labs in the Robotic Systems Research Department, where he pioneered the field of MEMS and started the silicon MEMS effort, leading a group of researchers in exploring and developing IC-based MEMS for applications in photonic and network systems. During a sabbatical year from Bell Labs, Dr. Gabriel was a Visiting Associate Professor at the Institute of Industrial Science, University of Tokyo, where he led joint projects at IBM Japan Research, Toyota Central Research Laboratories, and Ricoh Research Park. After leaving Bell Laboratories in 1991, he spent a year as a visiting scientist at the Naval Research Laboratory transferring micromechanics processing technology to the Nanoelectronics Processing Facility.

Dr. Gabriel holds an S.M. and a Ph.D. in Electrical Engineering and Computer Science from the Massachusetts Institute of Technology.

QUESTIONS SUBMITTED BY MEMBERS POST HEARING

FEBRUARY 29, 2012

QUESTIONS SUBMITTED BY MR. MILLER

Mr. MILLER. In light of today's constrained fiscal environment, can you talk to the importance of Developmental Test & Evaluation and its importance in controlling acquisition costs?

Secretary LEMNIOS. Developmental Test & Evaluation (DT&E) is one of the critical elements in controlling acquisition costs.

Since the late 1990s, major weapons systems have been failing initial operational testing and evaluation (IOT&E) at an increasing rate. Specifically, 25 percent of programs completing IOT&E between 1984 and 2000 failed either Effectiveness or Suitability. By the time Congress enacted and the President signed the Weapon Systems Acquisition Reform Act (WSARA), this failure rate had increased to 43 percent. Developmental Test & Evaluation is an important element of any program to ensure that deficiencies in acquisition programs are identified early—when it is most cost-effective to fix them—before programs reach operational testing or production milestones. Tight concurrency between DT&E and production decisions risks elevated retrofit costs that could have been avoided by proper phasing of DT&E. Robust DT&E across the Department's acquisition programs is the mechanism to deliver vital data.

Mr. MILLER. Congress created the position of Director of Developmental Test & Evaluation to ensure that deficiencies in programs are identified and addressed before those programs reach operational testing—because it's cheaper to find it and fix it early than it is to go back and fix it once it's already in production. The Director, Operational Test & Evaluation has 326 programs he's responsible for. The Director, DT&E has about 270 programs, but only ¼ of the staff of DOT&E. Do you believe OSD/DT&E is properly resourced in terms of both manpower and funding?

Secretary LEMNIOS. The FY13 President's Budget Request for OSD/DT&E manpower and funding would provide adequate resources to support the responsibilities of the office.

We have effectively used government detailees, government rotational assignments and technical staff across our Federally Funded Research and Development Centers to add capacity and bring technical depth into the office. These resources have allowed us to increase the capacity of DT&E and share best practices across the Department to effectively engage with major defense acquisition programs for which DT&E has statutory oversight.

Mr. MILLER. In 2009, Congress passed the Weapons System Acquisition Reform Act, which states that the Deputy Assistant Secretary of Defense for DT&E shall be the principal advisor to the Secretary of Defense and the Under Secretary for Acquisition, Technology, and Logistics, on developmental test and evaluation. It also states that the DDT&E will report to and be supervised by the Under Secretary. Do you believe the Department of Defense has complied with that legislation in terms of organizational and reporting structures it has put in place?

Secretary LEMNIOS. I believe the Department has complied with WSARA in terms of organizational and reporting structures. The DASD (DT&E) advises the Secretary of Defense and the Under Secretary of Defense for Acquisition, Technology and Logistics on all matters relating to developmental test and evaluation within the Department. In particular, the USD(AT&L), as the Milestone Decision Authority for Major Defense Acquisition Programs, relies on the DASD(DT&E) for advice on the demonstrated maturity of designs to enter initial production and on the adequacy of planned test programs at the beginning of Engineering and Manufacturing Development. The reporting chain through ASD(R&E) allows for alignment between DT&E and Systems Engineering efforts within the Department.

QUESTIONS SUBMITTED BY MR. LANGEVIN

Mr. LANGEVIN. I am pleased to see the emphasis on cybersecurity in each of your testimony, and I am also pleased that since last year's hearing on these matters the Department of Defense has identified cyber as one of the Department's seven key S&T areas. Secretary Lemnios, how are you ensuring that the various defense cyber

R&D efforts are both responsive to the DOD Strategy for Operating in Cyberspace and well-coordinated across agencies and individual laboratories?

Secretary LEMNIOS. The Department recently established the Cyber Investment Management Board (CIMB) in response to the National Defense Authorization Act (NDAA) for Fiscal Year 2011. This board is comprised of the Department's policy, acquisition, and technology leaders, to provide strategic oversight of the Department's cyber investments. To shape the Department's cyber S&T investments, the DoD Cyber S&T Working Group was established. It brings together representatives from across DoD's operational and S&T organizations and serves as focal point for coordination of cyber S&T across the DoD research community and related DoD organizations. This Department-wide Working Group was entrusted with the task of developing the Cyber S&T Roadmap that outlines the S&T gaps and leap-ahead capabilities needed to implement the DoD Strategy for Operating in Cyberspace. ASD (R&E) established a pair of cyber security program elements to address gap areas and create enhanced cross-laboratory collaboration among the Services and NSA at the technical level.

Mr. LANGEVIN. For the panel, what do we need to change to ensure that we are better able to identify and mitigate risks in the cyber domain?

Secretary LEMNIOS. In the short term, we are working with the commercial vendors to harden their IT products to be resilient to attack through efforts such as the Enduring Security Framework. Over the longer term, cyber research needs to mature like other scientific disciplines.

The science underpinning cyber is immature. To address these shortcomings, DoD research agencies such as the Air Force Office of Scientific Research fund university research on this topic. In addition, we have designed and initiated a cyber measurement campaign to assess the performance of cyber technology quantitatively. This campaign will develop a comprehensive, long-term plan to incorporate quantitative assessment into cyber S&T. This includes identifying the technical foundations for a cyber measurement framework, developing technically sound metrics, and developing capabilities to fill experimentation and test range gaps.

The DoD research community is working with the Intelligence Community and industry to provide early warning on new cyber risks, threats, and exploits. In 2011, the Cyber S&T Priority Steering Council developed a research roadmap covering the foundations of trust, resilient infrastructure, agile operations, and mission assurance as technical foundations for cyber security. The ASD(R&E) Cyber Applied Research and Advanced Development programs are also investing in tools for software and hardware analysis, hardening of tactical systems and moving target defenses. Research in these areas will enhance our ability to identify and mitigate operational and supply chain risks.

Mr. LANGEVIN. Secretary Lemnios, how would you characterize the health of the DOD labs and the R&D workforce?

Secretary LEMNIOS. I would characterize the health of the DoD laboratories as sufficient to meet current missions. However, I also see a need to strengthen this enterprise in an era where technology is globally available and innovation cycles have collapsed from years to months.

The DoD labs continue to serve as the core element of the Department's technical base. Indeed, the 37,000 scientists and engineers (S&E) in our labs represent 34 percent of the Department's total S&E population. Of these scientists and engineers, 26 percent possess Masters degrees while nine percent possess PhDs. This higher than the U.S. national S&E workforce, which is comprised of 21 percent Masters degrees and seven percent PhDs (FY2010 data from the National Science Board 2012 Science and Engineering Indicators report). DoD labs are part of a national security enterprise that works closely with other laboratories including Federally Funded Research & Development Centers (FFRDCs), University Affiliated Research Centers (UARCs), Academia, Industry and the Department of Energy (DOE) National labs in developing future warfighting technologies as well as providing quick response to immediate warfighting technical needs. Each lab has unique capabilities to meet specific missions that we closely monitor to ensure the Department's core technical competencies are addressed. Our labs support the most technically advanced military in the world and we believe the laboratories have played a major role in achieving this accomplishment.

Our laboratory system is a mix of corporate research labs, e.g., Naval Research Lab and Army Research Lab that maintain basic science as their primary focus, and engineering centers such as the Navy Warfare Centers and the Army's Research and Engineering Development Centers that maintain the Department's in-house system engineering expertise. The Services invest approximately one third of their basic science budgets to in-house programs. A recent review of the labs' basic

science program was conducted by the Defense Science Board and concluded the in-house basic research program is technically strong and healthy.

Mr. LANGEVIN. How does the Department utilize its STEM education and outreach programs to build the workforce we need for the future? How does the Department coordinate efforts and balance depth versus breadth with regards to STEM outreach?

Secretary LEMNIOS. The portfolio of DoD STEM education and outreach programs provides the Department with opportunities to provide an incentive to large numbers of young people across the country to pursue STEM education as well as to produce a high-quality STEM workforce. The ASD(R&E) chaired STEM Executive Board, which is comprised of Senior leadership from across the Department, serves as the primary mechanism for cross-Departmental coordination, and for Department-wide balance regarding depth and breadth.

DoD STEM programs at the undergraduate and graduate levels provide the Department a source of high-quality talent available for the DoD workforce. The Science, Mathematics and Research for Transformation (SMART) program, a scholarship-for-service program, provides students and current DoD employees an opportunity to pursue undergraduate or graduate degrees in one of 19 academic disciplines that are critical to the Department's STEM workforce needs. Students are required to provide a year of service in one of the DoD's laboratories for each year of funding received through SMART. To date, nearly 400 students have completed degrees and joined the DoD workforce.

The National Security Science and Engineering Faculty Fellowship (NSSEFF) provides research awards to 29 high-performing and distinguished university researchers and their students to conduct revolutionary research that is critical to DoD and national security. In turn, these 29 Fellows have attracted over 400 exceptional students and postdoctoral scholars. These researchers and their students have made significant contributions in critical areas to DoD. As evidence, their research productivity has resulted in over 1,000 presentations (418 international), 329 peer-reviewed publications and 39 patents. To ensure that DoD has direct connectivity with NSSEFF students, they have been engaged with DoD scientists and engineers at our laboratories and presented at a student focused conference.

Mr. LANGEVIN. Are there particular concerns that you have with regards to the health of the DOD R&D community that we need to address?

Secretary LEMNIOS. Maintaining the health of the DoD R&D community is one of my top priorities. As with any "thought-based" enterprise, the quality of people is at the top of the priority pyramid. Without high quality people, the health of the R&D community will be difficult to maintain. The DoD laboratory community (a subset of the overall R&D community) is distributed and diverse, and is comprised of 37,000 scientists and engineers (S&E) and represent 34 percent of the Department's total S&E population. Of these scientists and engineers, 26 percent possess Masters degrees while nine percent possess PhDs. This is higher than the U.S. national S&E workforce, which is comprised of 21 percent Masters degrees and seven percent PhDs. The overall R&D enterprise is of similarly high quality, and consists of public employees and uniformed Service members in DoD agencies and labs, researchers in academia, scientists and engineers in DoD-sponsored Federally-Funded R&D Centers (FFRDCs), research staff at the National Labs, and technologists at DoD prime contractors and small businesses. As the Department shifts its focus to the priorities called for in the new DoD strategy Sustaining U.S. Global Leadership: Priorities for 21st Century Defense, it is important that all of these sectors in the DoD R&D community remain fully engaged.

The President's FY 13 Budget Request is carefully crafted to ensure that all these sectors of the DoD R&D community can continue to contribute robustly to the evolving challenges.

Mr. LANGEVIN. For the panel, what do we need to change to ensure that we are better able to identify and mitigate risks in the cyber domain?

Dr. FREEMAN. I believe that Army S&T has sufficient funding and authorities to execute our cyber security efforts. S&T efforts are focused on securing our tactical networks, to provide a more secure foundation in which participants and components, including devices and software, are able to work together in near real time to: identify, prevent and anticipate cyber attacks, limit the spread of attacks across participating devices; minimize the consequences of attacks; and recover systems and networks to trusted states.

Mr. LANGEVIN. Are there particular concerns that you have with regards to the health of the DOD R&D community that we need to address?

Dr. FREEMAN. I have three major areas of concern—infrastructure, facilities and workforce. With regard to facilities, we are currently undertaking a comprehensive site survey to document the condition and capabilities of our S&T infrastructure and

facilities. Currently, the condition of facilities is examined at the installation level against a set of criteria that does not consider the specialized scientific requirements of our buildings. This approach does not give us the data required to truly understand the particular needs of the S&T facilities themselves, as opposed to the overall health of the installations on which they are located. This is a complicated undertaking, as the S&T enterprise is spread over five commands, and in many cases those commands are not the owners of the buildings they use. However, without this comprehensive survey, we will not be able to produce a true priority list for the most urgent areas of concern. With respect to our workforce, people are the Army's most valuable resource. Our Science and Technology workforce comprises government civilian scientists, technicians, engineers, wage grade workers and support personnel, as well as Soldiers and contract personnel who offer a wide array of specialties and abilities that allow Army science and technology labs and centers to cover the full spectrum of research, engineering and operational support for the nation, particularly the Warfighter. Developing and maintaining the world-class cadre of scientists, engineers, and technologists we have requires a three-phased approach:

1) invest in educational outreach initiatives to build a diverse, STEM capable talent source for the future workforce,

2) invest in research initiatives at the college and graduate school level to provide focus and generate expertise for the next generation of Army researchers, and

3) grow existing workforce capabilities through exchange programs and other authorities that provide for workforce development to help us maintain a vibrant, agile, well-educated cadre of Scientist and Engineers. Perhaps our most serious challenge is the contemplated workforce reductions necessitated by a severely constrained budget. Without a world-class cadre of scientists and engineers, and the infrastructure that supports their work, the Army S&T enterprise would be in serious trouble. Previous 1-n lists developed by each command have ranked our S&T positions lower in priority than other non-S&T positions, and a disproportionate loss of science and engineering talent could have devastating consequences for the Army. Continuing this practice, or following a "last in, first out" approach to reducing the workforce will have severe ramifications on our ability to provide our current and future Soldiers with the technology that enables them to defend America's interests and those of our allies around the world.

Mr. LANGEVIN. For the panel, what do we need to change to ensure that we are better able to identify and mitigate risks in the cyber domain?

Admiral KLUNDER. This is a very complicated question with few easy answers. First and foremost, every interface and interaction in cyberspace is a potential vulnerability. This is an asymmetric situation where the defender must protect everything and the attacker can succeed by circumventing a single defensive barrier. There are a number of key elements that comprise our cyber domain, each of which provides our adversaries with potential exploitable vulnerabilities and result in significant challenges for the defender. The most prevalent examples include software (applications as well as operating systems), hardware (including microprocessors and programmable logic such as field programmable gate arrays (FPGAs)), and lastly, the user. Complicating this picture is the fact that we lack the critical technological understanding of the information technology (IT) supply chain that we employ in our critical systems—resulting in pool of unknown vulnerabilities ripe for exploitation. The supply chain also includes DoD contractors and subcontractors and the challenges in protecting the integrity of their networks the data.

Additionally, embracing commercial practices and technology has made for an uneasy tradeoff between affordability and security. The results and effects are irreversible—large parts of our information infrastructure use foreign technologies and manufactured parts including chipsets, firmware, software applications, computer workstations and peripherals, and the very Internet routers moving DoD email through cyberspace. Software, likely the most critical of the three aforementioned key elements, is a major source of security failures and exploited vulnerabilities, and which largely remains a craft practiced by artisans, not engineers, despite the years of basic research into the mathematics of programming languages and algorithms. Defects from whatever source such as poorly defined protocols, inadequate testing, and ambiguous requirements and/or specifications create exploitable vulnerabilities. Expectations for patch management are assumed upon delivery and even prior to initial operation. Such practices have created a reactive rather than proactive environment, and in large part, these practices have been accepted by the military.

These challenges have resulted in the development of a comprehensive strategy that is comprised of three major tenets. The first tenet of our science and technology (S&T) program is to address software and the vulnerabilities that result from the previously illustrated example defects. The strategy includes developing tools to

automatically analyze and reduce layering and software growth. This results in smaller, simpler and more cohesive software that should improve module verification and system level testing. Next, tools are being developed to analyze commercial-off-the-shelf (COTS) shrink-wrap software (executable binary code). This analysis affords us two opportunities never available before: first, we can now detect the presence of embedded malicious code and second, we can "trim" unnecessary software features not required for use in our military environment. Our software strategy is also focused on developing tools for better whole code software verification and automated testing of both government-off-the-shelf (GOTS) and COTS software.

The second tenet of our S&T program is to address hardware vulnerabilities, with particular emphasis on the challenges we face with our supply chain. Efforts are currently focused on new anti-tamper technology to detect when unauthorized changes have occurred. These new approaches include, for example, hardware metering techniques and physical unclonable function (PUF) circuits. We see promise in these technologies and their value in protecting our hardware devices and the associated intellectual property.

Lastly, the third tenet of our S&T program is to address users and their associated behavior in cyber space. Realize, for example, the success of a phishing attack is predicated on the successful exploitation of the user. We recognize that we cannot address the vast pool of vulnerabilities across our cyber domain, therefore, in this tenet we are developing technologies (algorithms, techniques, sensors, etc.) to improve our detection and pro-active remediation of insecurities by characterizing behavior that is vulnerable to exploitation. These behavioral models are not only of the user, but the applications that operate on the network as well—with particular emphasis on identifying the genesis of "behavior" that typically results in insecurities.

Mr. LANGEVIN. Are there particular concerns that you have with regards to the health of the DOD R&D community that we need to address?

Admiral KLUNDER. U.S. military supremacy has been tightly linked to technological dominance. We need to maintain a strong R&D community and infrastructure to ensure our technical dominance.

The Department of Navy (DoN) R&D community is comprised of 15 major activities supporting the broad spectrum of DoN missions and technology requirements. The Naval Research Laboratory (NRL), 12 Warfare Centers, and 2 Systems Centers provide the critical science and engineering back-bone to ensure sustained technological superiority.

The Navy appreciates the Congress' continued support of Section 852, the Acquisition Workforce Fund that has authorized recruitment, training, and retention of scientists and engineers with the skills and experience necessary to meet our technical challenges. Additionally, the Navy appreciates the Congress' support of Section 219 enabling defense laboratories to invest in critical scientific and engineering capabilities of their respective mission areas. These have reaped positive benefits for the DoN.

The Naval Research Laboratory (NRL) conducts some of the most advanced research in the world, which depends on state-of-the-art, costly, high-precision equipment and facilities. Deferred investment in facilities hinders the recruitment and retention of a high quality workforce, causes millions of dollars in damage to laboratories and equipment, and results in many months of delays to critical research projects while laboratories are restored. Maintaining and revitalizing the Naval R&D infrastructure remains a concern. This is underscored even more during this period of tightened budgets.

The Warfare and Systems Centers are key conduits for integration technologies into existing and future systems and platforms. As was noted in the 2010 Naval Research Advisory Committee (NRAC) study on the Status and Future of the Naval R&D Establishment, the Warfare Centers and Systems Centers are a "gateway between current and emerging technologies and future Naval warfare capabilities." Conscious and sustained investment in the workforce and infrastructure of these activities is essential for our future security.

Mr. LANGEVIN. For the panel, what do we need to change to ensure that we are better able to identify and mitigate risks in the cyber domain?

Dr. WALKER. Our vision is for an assured cyber advantage across air, space, cyber, C4ISR (command, control, communications, and computer (C4) intelligence, surveillance, and reconnaissance (ISR)), and infrastructure. An end state would include assured air, space and cyber operations conducted globally through a wide spectrum of cyber conditions and threats; a full spectrum set of cyber capabilities to reliably deliver a broad range of effects; persistent, global, cyber situation awareness; integrated command and control for kinetic and cyber weapon effects; assured, reliable,

affordable supply chains for cyber infrastructure; and highly skilled and effective cyber-warriors and workforce. Successfully accomplishing such a vision requires not just Air Force leadership but the ability to leverage technology developments from industry, other Services and government agencies to develop capabilities to meet Air Force requirements.

To ensure we are better able to identify and mitigate risks in the cyber domain, we need to achieve the following four strategic goals:

1. Assure and Empower the Mission—Enable Air Force missions to be assured while cyber threats are avoided, identified, contained and/or defeated; conduct effective full spectrum operations while maintaining real-time situational awareness for command and control.

2. Create Next-Generation Cyber Warriors—Select, educate, train, and augment cyber warriors for superior performance; enable visualization of a complex cyber common operational picture.

3. Enhance Agility and Resilience—Develop resilient, agile architectures that can avoid, fight through, and recover from attacks; intelligently mix government and commercially-developed technology to achieve both trust and affordability.

4. Invent Foundations of Trust and Assurance—Provide the Air Force with organic capabilities to mitigate supply chain intervention and to establish hardware and software root-of-trust; create the foundations of trust for applications, functions and missions; develop the mathematical algebra to represent missions, applications and infrastructure for provably correct mission characterizations in contested environments.

Mr. LANGEVIN. Are there particular concerns that you have with regards to the health of the DOD R&D community that we need to address?

Dr. WALKER. The health of the R&D community depends on our ability to retain a strong science, technology, engineering, and mathematics (STEM) workforce. The Air Force is developing measures through our STEM Advisory Council and Bright Horizons, the Air Force STEM Workforce Strategic Roadmap, to improve our ability to attract, retain, shape, and manage our mission critical STEM workforce. Bright Horizons discusses the national challenge of producing STEM-degreed talent and the importance of Air Force maintaining a competitive edge by recruiting and retaining STEM personnel.

The Air Force is confronted with supply and demand challenges that require us to strategically manage our STEM workforce. These problems include a declining STEM talent pool from our educational system, lack of diversity in our future STEM workforce, worldwide competition for STEM talent, and low attraction to Air Force STEM careers.

Through Bright Horizons, we are identifying current and future STEM workforce requirements, developing strategies to address any gaps between them, and establishing methods to measure for success. Priorities for the Air Force include hiring of STEM-degreed individuals, STEM interns, and Science, Mathematics and Research for Transformation (SMART) Scholars; and protecting STEM training and education resources. Our STEM workforce is critical to the Air Force, and our success depends upon implementing the initiatives within Bright Horizons.

Mr. LANGEVIN. For the panel, what do we need to change to ensure that we are better able to identify and mitigate risks in the cyber domain?

Dr. GABRIEL. [The information was not available at the time of printing.]

Mr. LANGEVIN. Are there particular concerns that you have with regards to the health of the DOD R&D community that we need to address?

Dr. GABRIEL. [The information was not available at the time of printing.]

QUESTIONS SUBMITTED BY MR. SHUSTER

Mr. SHUSTER. The Department of Defense invests millions of dollars each fiscal year in research and development through our universities, yet most of these initiatives do not advance to the applied and advanced research levels. What can be done to assist universities with technology transfer in order to ensure DoD is getting a return on their investments? Would the Department of Defense consider partnership programs with experts in the field of technology transfer to assist universities cross the bridge from innovation to commercialization?

Secretary LEMNIOS. The Department's funding of research and development through universities is principally executed through 6.1 basic research project funds. These efforts support long term investments in new technologies and concepts where discovery is needed and the underlying technology base needs to be developed. While our universities excel at basic research, not all funded concepts will advance to applications. Many will set the foundation for future applications, while others

will be overcome by competing ideas in the advanced research process. As such, the return on investment is measured in long timelines with the understanding that today's basic research investments provide future options that would not be available without seed research funding.

For those concepts that are reaching maturity, the Department is launching a pilot effort to facilitate the transfer of university-developed innovation to industry for commercialization. This effort involves inviting industry scientists familiar with the development of advanced technologies from firms from the defense industrial base to attend the Department's Multidisciplinary University Research Initiative (MURI) project reviews. By inviting industry to these reviews, which had not been done before, we hope to facilitate early stage information exchange between university researchers and industry product developers. MURI projects are DoD funded multi-university and multidisciplinary projects that bring together prominent scientists to develop new concepts in emerging areas of basic science; there are approximately 150 MURI projects currently underway. Industry attendance at the reviews provides the firms insight into the university research and opportunities for them to cement early relationships with the researchers in areas of interest to the firm. We believe developing these early relationships while the research is underway will facilitate the transfer of university developed technology into commercial products much faster and more completely than is done today. At the first meeting of this pilot effort sixteen firms from the defense industrial base attended and interacted with the university researchers. The response from industry and universities to the pilot effort has been positive. The next industry-university MURI review is planned to occur around August 8–10, 2012.

We are starting with the MURI program because it has a demonstrated track record of major accomplishments and proven to be an excellent source of new and very innovative concepts that can lead to new products. As this pilot effort progresses we plan to host joint workshops with our industrial base and academic associations to discuss ways to apply the lessons learned from this pilot program to other DoD-funded university and defense lab basic research programs.

Mr. SHUSTER. As chairman of the Panel on Business Challenges within the Defense Industry, I have seen the incredible capability that Small Businesses can bring to the table to quickly and effectively innovate and commercialize technology. What is the Department of Defense doing to utilize small businesses to facilitate technology transfer and help advance University and Defense Lab research progress to full-scale production? What mechanisms do you have to transition the efforts of the S&T community, including Small Business Innovative Research (SBIR) programs, into major acquisition programs of record?

Secretary LEMNIOS. There are a number of programs available to transition small business research efforts into programs of record.

- The Rapid Innovation Fund was established by section 1073 of the Ike Skelton National Defense Authorization Act for Fiscal Year 2011 which gives priority to small business technology that resolve joint urgent, or critical national security needs. The RIF focuses on relatively mature technology that can be transitioned into an acquisition program, or made available to the Department as a new commercial product within 24 months. The Department is beginning contract awards and will have a better sense of the success of the RIF in 3Q FY 2013.
- The DoD SBIR/STTR Program currently has two programs to encourage the transition of SBIR and Small Business Technology Transfer (STTR) research into DoD acquisition programs: the Phase II Enhancement Program, and the Commercialization Pilot Program.
  - —The SBIR/STTR Phase II Enhancement Program facilitates transition by providing SBIR/STTR Phase II awardees with additional funds when there is a strong pull for the awardee's technology. To qualify for the enhancement funds, the awardee must provide matching funds from a non-SBIR/STTR source; e.g., a DoD acquisition program or the private sector.
  - —The Commercialization Pilot Program accelerates commercialization and fielding of capabilities through enhanced collaboration among the small business, prime contractors, and the DoD science and technology acquisition communities. Participation in the CPP is by invitation, and participants receive a variety of assistance services and/or opportunities to include modifications to existing Phase II contracts with additional non-SBIR funding and/or additional SBIR funding beyond the normal SBIR funding guidelines. The purpose of the additional funds is expand research, development, test, or evaluation that leads to an accelerated transition and commercialization. DoD Components have criteria and processes to identify projects with the potential for rapid transition.
- The Department's Rapid Reaction Fund (RRF) and Quick Reaction Fund (QRF) programs have been used to accelerate the transition of technology developed by

small businesses. One example is the Augmented Reality Visualization of the Common Operating Picture (ARVCOP) project. This concept was funded through RRF and resulted in an augmented reality tactical display that allows sailors to visualize hazards, sea lanes, markers, etc., in reduced visibility. ARVCOP is currently being used by the Navy, and a variant of the capability is available on the commercial market.

QUESTIONS SUBMITTED BY MR. RUPPERSBERGER

Mr. RUPPERSBERGER. What is the long term investment strategy in 6.1 basic science and research for the Department of Defense? Which areas are being funded strategically to support the long term needs of our service and intelligence customers?

Secretary LEMNIOS. DoD basic research supports transformational science with the potential to revolutionize the Nation's warfighting capabilities. In addition, DoD basic research helps educate well over ten thousand new scientists and engineers every year, assuring the Nation's continued national security, economic vitality, and technical preeminence.

Each of the Military Departments pursues a strategic focus on numerous basic science topics including but not limited to, physics, lasers and optics, space science, geophysics, oceanographic and atmospheric sciences, acoustics, chemistry, biology, materials, mathematics, information and computer sciences, decision-making, psychology, sociology, aerospace engineering, electrical engineering, and mechanical engineering.

In addition, we have developed a set of six cross-cutting "strategic basic science investment areas", around which we are shaping the Department's basic research investment. The six are:

Engineered Materials: materials not found in nature, and designed for ultra-efficient microelectronics, smaller radars, and perhaps the next generation of stealth.

Synthetic Biology: exploiting the convergence of nano-engineering and life at the cellular level for the efficient production of food, fuel, energy, and new sensors.

Quantum Information Science: new physical paths towards ultra-secure communications, precise navigation without GPS, and ultra-fast computation.

Cognitive Neuroscience: understanding the neuro-pathways in the human brain and the science of perception, training, and trauma.

Modeling Human Behavior: understanding how the ensemble of humans, known as society, expresses its character, rules, and cultures.

Nanoscience and nanotechnology: where advances continue unabated, and power new future technologies.

Mr. RUPPERSBERGER. How is the Department of Defense translating ideas into practice? Is there a technology commercialization strategy other than the use of SBIR and STTR funds?

Secretary LEMNIOS. The Department's technology transition strategy identifies new mechanisms to engage with non-traditional performers including small businesses and opens new channels for small business to access Department facilities and resources. This strategy is focused on improved transition or commercialization of small business-developed technologies through a variety of opportunities including:

- Provide access for small businesses to the Department's training and test facilities to test and refine technology development. For example, the Joint Experimental Range Complex (JERC) at the U.S. Army Yuma Proving Ground provides opportunities for small businesses to test and refine their technologies in realistic DoD operational environments, and with feedback from operational personnel. The test and refine process increases the probability of successful transition of the small business technology into a DoD program of record, or into commercialization as a new product.
- Provide small businesses access to DoD laboratories' intellectual property, personnel, equipment, data, facilities, or other resources through Cooperative Research and Development Agreements (CRADAs). A CRADA facilitates technology transfer between the federal government and private sector by enabling technical exchange and information sharing. For example, The Army Research, Development, and Engineering Center at Picatinny Arsenal established an agreement with the County College of Morris County, N.J. to provide collaborative work space with 18 small businesses. The CRADA provides the small businesses a structure to use the lab's facilities and equipment to develop their technology, and to work collaboratively with lab personnel on technology development efforts. The lab and the college provide training and business support

for the companies, and the companies receive funding and staff support from the New Jersey Commission on science and Technology and New Jersey Incubation and R&D funding programs.

- The Department's Rapid Reaction Fund (RRF) and Quick Reaction Fund (QRF) programs focus on developing and fielding solutions to operational challenges. One example of a successful developmental effort by a small business is the Augmented Reality Visualization of the Common Operating Picture (ARVCOP) project. This concept was funded through RRF and resulted in an augmented reality tactical display that allows sailors to visualize hazards, sea lanes, markers, etc., in reduced visibility. ARVCOP is currently being used by Navy riverine forces and a variant of the capability is available on the commercial market. In a similar engagement model with industry, the QRF funded the Inflatable Satcom Antenna project in which a small business developed 1.8m and 2.4m satellite antennas that can be folded into duffel bags for transportation. The antennas can be quickly set up and broken down for storage. This capability greatly reduces the logistics requirements (size and weight) when compared to moving similar sized traditional satcom antennas. The Marine Corps is using the Inflatable Satcom Antenna systems.
- The Rapid Innovation Fund (RIF) was established pursuant to section 1073 of the Ike Skelton National Defense Authorization Act for Fiscal Year 2011 which gives priority to small businesses whose technologies resolve joint urgent, or critical national security needs. The RIF focuses on relatively mature technologies that can be transitioned into an acquisition program, or made available to the Department as a new commercial product within 24 months. In September 2011, the Department issued solicitations for RIF proposals and received over 3500 responses. Approximately 160–180 of the responses will receive contract awards. The RIF represents an experimental new mechanism for the Department of Defense to engage with the small business community. The Department is beginning contract awards and will have a better sense of the overall effectiveness of this congressionally-established program in 3Q FY 2013.

Mr. RUPPERSBERGER. What is DARPA doing to counter emerging threats? What areas require more investments or reallocation of funds to prevent technological surprise?

Dr. GABRIEL. DARPA has developed several analytic frameworks. These frameworks are designed to be deeply quantitative, to reveal the essential parameters governing a decision space, and to reveal gaps and opportunities. Accessible to technical and operational executives, the analytic frameworks are structured to ensure the Agency, and the Department, are better able to choose and focus investments. Ultimately, these frameworks have the power to reveal areas where the Department is divergent with threats and technological trends and thus, need new options.

For example, following the insights from our ISR analytic framework, we shifted our investments from sensor development to exploitation.

Mr. RUPPERSBERGER. What new aerospace platforms is DARPA developing to prevent technological surprise? For example are you working on anything related to rapid access to space systems, long range global strike or high speed rotorcraft?

Dr. GABRIEL. Several programs in the Tactical Technology Office (TTO) at DARPA address the prevention of technological surprise through aerospace platform and technology development in the areas referenced. A brief description of each program is below.

The Triple Target Terminator program seeks to develop and demonstrate a high speed, long range aerodynamic missile to defeat current and projected enemy aircraft, cruise missiles, and surface to air defense targets.

The Hypersonic Technologies program is developing and testing an unmanned, rocket-launched, maneuverable, hypersonic air vehicle capable of very long range, long duration prompt global reach missions.

Space Enabled Effects for Military Engagements seeks to demonstrate technologies enabling small, disposable, affordable satellite constellations capable of rapid deployment for persistent tactical military ISR applications.

The Airborne Launch Assist Space Access program is developing a system to enable launch of tactically responsive payloads within 24 hours of request at the cost of $1M per flight in the 100 pound payload class.

System F6 is developing and testing the feasibility and benefits of replacing large monolithic spacecraft with a cluster of wirelessly-interconnected modules capable of secure, real-time resource sharing.

The Vertical Take-Off and Landing (VTOL) X–Plane program will develop and demonstrate in flight VTOL technologies to facilitate advancement of the next generation of military rotorcraft with significantly improved speed, range, endurance, efficiency; and the ability to hover at altitude.

QUESTIONS SUBMITTED BY MR. SCHILLING

Mr. SCHILLING. How do you see the role of cyber security advancing under the new budgetary constraints? What will be the main obstacles and how do you plan to work around those obstacles?

Secretary LEMNIOS. The President of the United States and the Secretary for Defense released new strategic guidance, Priorities for 21st Century Defense, which identifies cyber as a key part of the January 2012 strategy. Advancement of Cyber S&T is a critical element to enable military, intelligence, business operations, and command and control of full spectrum military operations, as recognized in the DoD Strategy for Operating in Cyberspace. The importance of meeting cyber security capability needs is reflected in the designation of cyber as one of the Department's seven key S&T areas and an increase in the President's Budget Request from $453 million for cyber S&T activities in FY12 to $486 million in FY13. This is one of the few major investment areas that actually showed growth in the FY13 Request and continues to move higher on our list of investment priorities.

As the ASD (R&E), I established the DoD Cyber S&T Working Group to shape the Department's cyber S&T investments. I chartered the Department-wide Working Group to develop the Cyber S&T Roadmap. The implementation of the Cyber S&T Roadmap and continued success in developing capabilities through the ASD(R&E) cyber security program elements will enhance cyber security.

The Department has benefited tremendously from using relatively inexpensive and fast-moving commercial technology, but, the resulting systems have been simple and inexpensive to attack while being difficult and costly to defend. This is exactly the situation our strategy will remedy by creating systems with built-in resiliency and resistance features to continually change the cost and complexity relationships on which attackers currently rely. Our S&T strategy is designed to drive up the cost of an adversary's efforts to attack compared to the efforts to defend our systems. Focused S&T investment, even in an era of tightened budgets, is necessary to drive down the cost of the operational effort to defend systems.

Mr. SCHILLING. How will the funding of research and development inhibit the growth of DOD technical and science capabilities? What will be the hardest hit areas?

Secretary LEMNIOS. The FY 2013 President's Budget Request (PBR) for DoD science and technology is $11.861 billion, which represents a balanced, but modest, decline of $386 million compared to the FY 2012 PBR of $12.247 billion. This is a decline of 4.73 percent when adjusted for inflation. Within this budget request, the Department decided to more strongly support sustainment of Basic and Applied Research. While a decline of just less than 5 percent buying power in the science and technology program does have a small impact, it is manageable, and reasonable when taken in the context of the overall DoD budget decline. Funding reductions occurred in all Services, and seemed to cluster around military engineering, weapons research, and energy research. Specific areas with greater risk in the Army include: military engineering technology development for installations and field operations, and applied topographical research for geospatial products; plus weapons, munitions, missile, and rocket technology development for small precision munitions, such as mortars. Navy reductions were the least of the Services and included technology development to improve logistics operations, sustainment, and some power & energy programs. Within the Air Force, reductions occurred and additional risk was accepted in the following areas: laser protection for anti-access standoff munitions and for aircraft pilot visors; novel navigation techniques for non-permissive environments; space precision navigation and timing; trusted systems for avionics devices; and advanced airborne networked and wide-band communications. Funding reductions also occurred in the following Defense-wide technology areas: National Defense Education Program; human, social, cultural, behavior modeling; Joint Experimentation; Joint Capability Technology Demonstrations; counter weapons of mass destruction; biomaterials technologies; machine intelligence; cognitive computing; command, control & communication systems; and advanced electronics. Although the reductions are numerous, most are below $20 million in magnitude, and funding for the Department's highest priority technology programs was protected.

Mr. SCHILLING. How will DARPA's role be changed in the new DOD force structure and will DARPA change its decision-making processes on what projects to pursue? If there are changes, what will they be?

Dr. GABRIEL. There are no entitlements to programs or people at DARPA, and we have no internal facilities or infrastructure. Since 1992, the total number of program managers has remained unchanged at or below 120. These technical experts serve for a tour of 3 to 5 year, putting their careers in suspended animation in serv-

ice to country. Going forward, it is imperative that DARPA continues to maintain maximum flexibility to rapidly hire the best technical minds in our nation to help fulfill the DARPA's singular mission to create and prevent strategic surprise.

When determining what projects to choose, the challenge isn't coming up with ideas, but rather choosing among them. We ask ourselves three questions in determining what projects to pursue:

- Will it be game changing and have a lasting impact for the Department and National Security?
- Does it require DARPA technical expertise and agility?
- How does it contribute to the balance of existing DARPA investments?